Designation: E 1360 – 90 (Reapproved 2000)ε1

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 E 1360; 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.

ε[1] NOTE—Keywords were added editorially in July 2000.

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 consists of 558 atlas samples that fall 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.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1535 Practice for Specifying Color by the Munsell System[3]

D 1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials[3]

E 284 Terminology of Appearance[3]

E 308 Practice for Computing the Colors of Objects by Using the CIE System[3]

E 1164 Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation[3]

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 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 $\pm L$ and the opponent-color scales $\pm j$ (yellowness-blueness) and $\pm g$ (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.

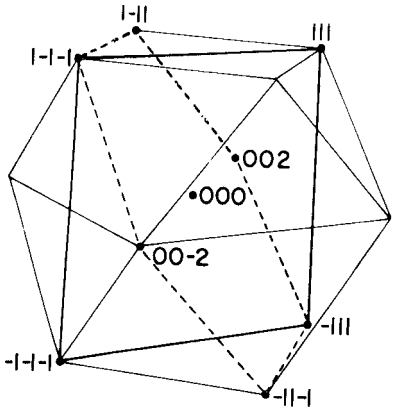
NOTE 1—The conventional terms yellowness, greenness, blueness, and redness are used throughout this practice for convenience. However, this does not imply that the j and g axes indicate the locations of the corresponding unitary hues: The $+j$ axis closely approximates the direction toward unitary yellow; but the $+g$ axis divides the green and blue

[1] This practice is under the jurisdiction of ASTM Committee E 12 on Color and Appearanceand is the direct responsibility of Subcommittee E12.07 on Color Order Systems US TAG TC 187.

Current edition approved May 25, 1990. Published August 1990.

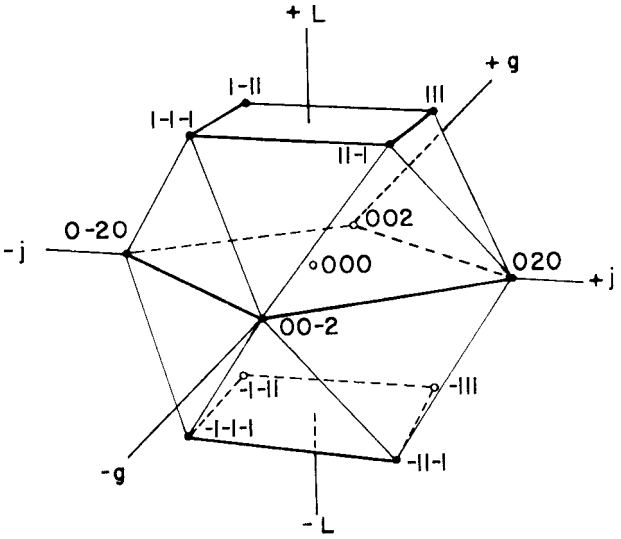
[2] The boldface numbers in parentheses refer to a list of references at the end of this practice.

[3] *Annual Book of ASTM Standards*, Vol 06.01.



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, **(10).** Copyright © 1987, John Wiley & Sons.

FIG. 2 Cuboctahedron Showing Vertical and Oblique Planes



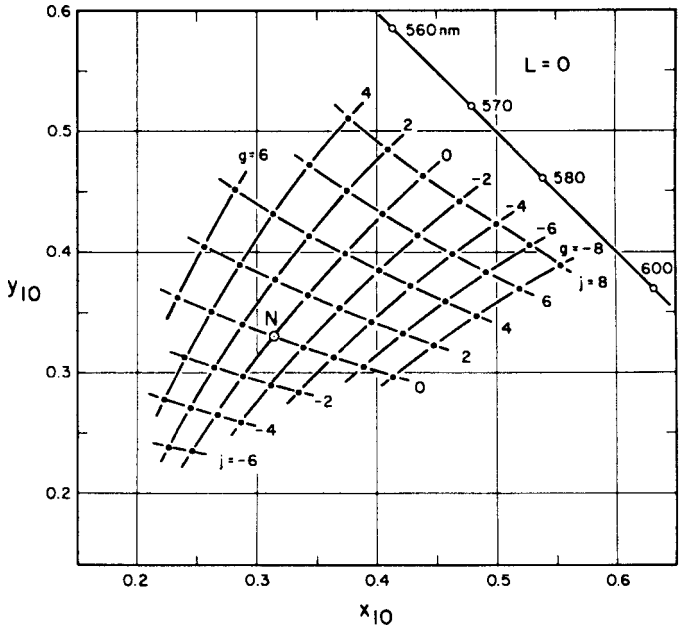
NOTE 1—Cuboctahedron showing location of *L, j,* and *g* axes through its center and the locations and *L, j, g* coordinates of the center point and its 12 nearest neighbors. The lattice of the OSA-UCS system is derived by extending this unit in all directions to the extremes of color space. In this 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, **(10).** Copyright © 1987, John Wiley & Sons.

FIG. 1 Cuboctahedron Showing Axes and Horizontal Planes

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 **(2).**

3.1.4 *OSA-UCS samples, n*—current Optical Society of America physical exemplification of the OSA-UCS color system, consisting 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:*



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., **(11).** Copyright© 1982, John Wiley & Sons.

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

3.2.1 The definitions in Practice D 1535 and Definitions E 284 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 E 308 and Practice E 1164. Transformation equations **(3)** 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 as (0,0,0), and illuminated with natural or artificial daylight. OSA-UCS atlas samples are used as references in judging test-specimen color.

5. Significance and Use

5.1 Notational systems that specify and identify colors have proved to be very useful. This practice describes how to assign an OSA-UCS notation to a color specimen. This notation gives its position within the color space determined by the Optical Society of America Committee on Uniform Color Scales to represent the closest possible approximation to a color space in which equal distances equate to equal visually perceived differences. The cuboctahedral sampling fills the color space with a more closely spaced set of samples than would a cubic lattice or samples placed on polar coordinates.

6. Apparatus (Visual Method)

6.1 *Optical Society of America Uniform Color Scales*, set of 558 samples.[4]

6.2 *Daylight Illuminating Equipment*, as described in Practice D 1729 or equivalent. A source simulating CIE standard illuminant D_{65} is preferred.

[4] Available from the Optical Society of America, 2010 Massachusetts Ave., NW, Washington, DC 20036.

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

TABLE 1 *Continued*

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}
	−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
	−4	−2	18.10	0.2824	0.2474		1	−3	25.00	0.3714	0.3330
	−4	0	18.23	0.2574	0.2531		1	−1	25.60	0.3432	0.3439
	−4	2	18.26	0.2323	0.2591		1	1	25.96	0.3145	0.3555
	−4	4	18.18	0.2071	0.2655		1	3	26.02	0.2849	0.3682
							1	5	25.75	0.2541	0.3820
	−2	−6	18.09	0.3658	0.2683						
	−2	−4	18.58	0.3386	0.2754		3	−9	21.97	0.4933	0.3291
	−2	−2	18.96	0.3112	0.2829		3	−7	23.24	0.4646	0.3408
	−2	0	19.19	0.2836	0.2910		3	−5	24.42	0.4357	0.3529
	−2	2	19.27	0.2555	0.2995		3	−3	25.46	0.4063	0.3659
	−2	4	19.16	0.2268	0.3086		3	−1	26.26	0.3764	0.3797
	−2	6	18.87	0.1977	0.3182		3	1	26.77	0.3459	0.3946
							3	3	26.89	0.3144	0.4109
	0	−10	16.86	0.4609	0.2831		3	5	26.54	0.2812	0.4292
	0	−8	17.71	0.4320	0.2914						
	0	−6	18.50	0.4029	0.3004		5	−9	21.43	0.5332	0.3520
	0	−4	19.19	0.3736	0.3099		5	−7	22.89	0.5039	0.3664
	0	−2	19.73	0.3440	0.3200		5	−5	24.31	0.4738	0.3815
	0	0	20.10	0.3139	0.3309		5	−3	25.58	0.4432	0.3975
	0	2	20.24	0.2831	0.3426		5	−1	26.60	0.4119	0.4146
	0	4	20.12	0.2512	0.3553		5	1	27.26	0.3801	0.4330
	0	6	19.71	0.2180	0.3692		5	3	27.45	0.3470	0.4535
							5	5	27.01	0.3119	0.4773
	2	−10	16.59	0.5043	0.3094						
	2	−8	17.65	0.4739	0.3203		7	−9	20.62	0.5724	0.3707
	2	−6	18.66	0.4430	0.3320		7	−7	22.22	0.5431	0.3883
	2	−4	19.57	0.4118	0.3443		7	−5	23.82	0.5127	0.4067
	2	−2	20.32	0.3801	0.3577		7	−3	25.31	0.4814	0.4261
	2	0	20.84	0.3479	0.3719		7	−1	26.55	0.4493	0.4468
	2	2	21.07	0.3147	0.3874		7	1	27.38	0.4165	0.4694
	2	4	20.93	0.2800	0.4046		7	3	27.63	0.3823	0.4948
	2	6	20.35	0.2430	0.4243		7	5	27.09	0.3460	0.5249
	4	−10	16.06	0.5486	0.3328	0	−6	0	26.50	0.2457	0.2349
	4	−8	17.28	0.5175	0.3468		−6	2	26.52	0.2260	0.2391
	4	−6	18.50	0.4853	0.3618						
	4	−4	19.64	0.4525	0.3775		−4	−2	27.49	0.2872	0.2598
	4	−2	20.61	0.4192	0.3942		−4	0	27.68	0.2655	0.2652
	4	0	21.32	0.3851	0.4124		−4	2	27.75	0.2437	0.2708
	4	2	22.65	0.3500	0.4324		−4	4	27.68	0.2217	0.2767
	4	4	21.49	0.3130	0.4551						
							−2	−4	28.12	0.3350	0.2835
	6	−10	15.33	0.5915	0.3515		−2	−2	28.58	0.3118	0.2903
	6	−8	18.65	0.5608	0.3691		−2	0	28.88	0.2883	0.2974
	6	−6	18.02	0.5283	0.3877		−2	2	29.00	0.2644	0.3049
	6	−4	19.36	0.4948	0.4072		−2	4	28.93	0.2401	0.3128
	6	−2	20.55	0.4603	0.4282						
	6	0	21.45	0.4250	0.4508		0	−8	27.22	0.4130	0.2972
	6	2	21.89	0.3885	0.4758		0	−6	28.14	0.3886	0.3050
	6	4	21.91	0.3498	0.5046		0	−4	28.93	0.3640	0.3131
							0	−2	29.57	0.3391	0.3218
−1	−5	−1	22.61	0.2618	0.2405		0	0	30.00	0.3138	0.3310
	−5	1	22.69	0.2397	0.2454		0	2	30.20	0.2882	0.3406
	−5	3	22.66	0.2176	0.2504		0	4	30.13	0.2617	0.3511
							0	6	29.77	0.2345	0.3622
	−3	−3	23.36	0.3099	0.2670						
	−3	−1	23.67	0.2856	0.2734		2	−8	27.35	0.4469	0.3230
	−3	1	23.81	0.2612	0.2801		2	−6	28.50	0.4212	0.3327
	−3	3	23.81	0.2364	0.2871		2	−4	29.52	0.3951	0.3429
	−3	5	23.64	0.2113	0.2945		2	−2	30.36	0.3688	0.3537

TABLE 1 *Continued*

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}
							2	0	30.95	0.3421	0.3652
	−1	−7	22.97	0.3911	0.2841		2	2	31.25	0.3147	0.3775
	−1	−5	23.68	0.3652	0.2917		2	4	31.19	0.2863	0.3909
	−1	−3	24.27	0.3392	0.2996		2	6	30.73	0.2567	0.4056
	−1	−1	24.70	0.3129	0.3081						
	−1	1	24.94	0.2861	0.3171		4	−8	27.16	0.4824	0.3475
	−1	3	24.96	0.2588	0.3266						
	−1	5	24.74	0.2308	0.3369						
		A: Full-Step Colors						A: Full-Step Colors			
	4	−6	28.55	0.4555	0.3594		9	−7	31.66	0.5387	0.4045
	4	−4	29.81	0.4283	0.3719		9	−5	33.55	0.5126	0.4214
	4	−2	30.87	0.4007	0.3852		9	−3	35.29	0.4858	0.4389
	4	0	31.64	0.3726	0.3993		9	−1	36.76	0.4585	0.4578
	4	2	32.05	0.3438	0.4146		9	1	37.79	0.4305	0.4780
	4	4	32.01	0.3139	0.4315		9	3	38.24	0.4017	0.5003
	4	6	31.42	0.2822	0.4506						
						2	−4	0	39.65	0.2716	0.2739
	6	−8	26.63	0.5186	0.3697		−4	2	39.76	0.2523	0.2792
	6	−6	28.24	0.4910	0.3841		−4	4	39.71	0.2329	0.2847
	6	−4	29.74	0.4629	0.3992						
	6	−2	31.02	0.4343	0.4152		−2	−4	40.18	0.3324	0.2895
	6	0	31.99	0.4052	0.4323		−2	−2	40.73	0.3121	0.2956
	6	2	32.52	0.3753	0.4510		−2	0	41.10	0.2917	0.3020
	6	4	32.49	0.3440	0.4720		−2	2	41.28	0.2709	0.3087
							−2	4	41.24	0.2498	0.3156
	8	−8	25.82	0.5544	0.3884						
	8	−6	27.59	0.5267	0.4057		0	−6	40.32	0.3783	0.3083
	8	−4	29.29	0.4982	0.4237		0	−4	41.22	0.3571	0.3155
	8	−2	30.78	0.4691	0.4427		0	−2	41.95	0.3396	0.3231
	8	0	31.95	0.4392	0.4632		0	0	42.46	0.3138	0.3310
	8	2	32.61	0.4086	0.4855		0	2	42.72	0.2918	0.3392
	8	4	32.59	0.3765	0.5111		0	4	42.71	0.2692	0.3481
							0	6	42.40	0.2460	0.3575
1	−5	1	32.01	0.2493	0.2580						
	−5	3	32.01	0.2298	0.2628		2	−6	40.90	0.4058	0.3329
							2	−4	42.04	0.3834	0.3417
	−3	−3	32.80	0.3107	0.2760		2	−2	42.97	0.3609	0.3508
	−3	−1	33.14	0.2897	0.2818		2	0	43.64	0.3380	0.3604
	−3	1	33.34	0.2686	0.2879		2	2	44.01	0.3147	0.3706
	−3	3	33.36	0.2471	0.2041		2	4	44.03	0.2907	0.3816
	−3	5	33.22	0.2254	0.3009		2	6	43.66	0.2658	0.3934
	−1	−5	33.21	0.3577	0.2971		4	−6	41.17	0.4346	0.3570
	−1	−3	33.86	0.3355	0.3041		4	−4	42.55	0.4114	0.3674
	−1	−1	34.34	0.3131	0.3114		4	−2	43.70	0.3878	0.3783
	−1	1	34.64	0.2903	0.3193		4	0	44.56	0.3639	0.3899
	−1	3	34.71	0.2671	0.3274		4	2	45.05	0.3395	0.4023
	−1	5	34.54	0.2434	0.3361		4	4	45.11	0.3143	0.4156
	1	−7	32.90	0.4092	0.3158		6	−6	41.07	0.4646	0.3799
	1	−5	33.91	0.3859	0.3240		6	−4	42.70	0.4406	0.3921
	1	−3	34.77	0.3624	0.3328		6	−2	44.09	0.4162	0.4051
	1	−1	35.42	0.3386	0.3420		6	0	45.14	0.3914	0.4188
	1	1	35.83	0.3144	0.3517		6	2	45.76	0.3660	0.4335
	1	3	35.96	0.2896	0.3620		6	4	45.86	0.3399	0.4496
	1	5	35.76	0.2641	0.3731						
							8	−6	40.58	0.4952	0.4008
	3	−9	31.73	0.4645	0.3310		8	−4	42.45	0.4706	0.4152
	3	−7	33.10	0.4403	0.3406		8	−2	44.07	0.4456	0.4303
	3	−5	34.35	0.4159	0.3507		8	0	45.32	0.4202	0.4464
	3	−3	35.42	0.3912	0.3613		8	2	46.08	0.3941	0.4637
	3	−1	36.26	0.3662	0.3726		8	4	46.23	0.3672	0.4829
	3	1	36.81	0.3408	0.3845						
	3	3	37.01	0.3146	0.3973		10	−6	39.74	0.5257	0.4192
	3	5	36.79	0.2873	0.4113		10	−4	41.81	0.5009	0.4359
							10	−2	43.63	0.4756	0.4532
	5	−7	32.96	0.4727	0.3643		10	0	45.09	0.4498	0.4719
	5	−5	34.45	0.4474	0.3764		10	2	45.99	0.4233	0.4920
	5	−3	35.76	0.4217	0.3891						
	5	−1	36.80	0.3957	0.4026	3	−3	−1	48.63	0.2926	0.2878
	5	1	37.51	0.3691	0.4170		−3	1	48.89	0.2738	0.2933
	5	3	37.78	0.3417	0.4327		−3	3	48.97	0.2549	0.2991

TABLE 1 *Continued*

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}
	5	5	37.53	0.3132	0.4500						
							−1	−5	48.76	0.3524	0.3010
	7	−7	32.47	0.5058	0.3858		−1	−3	49.55	0.3329	0.3073
	7	−5	34.18	0.4798	0.4002		−1	−1	50.15	0.3131	0.3139
	7	−3	35.72	0.4535	0.4153		−1	1	50.53	0.2932	0.3208
	7	−1	36.98	0.4266	0.4313		−1	3	50.66	0.2729	0.3279
	7	1	37.85	0.3992	0.4485						
	7	3	38.20	0.3709	0.4672		1	−5	49.74	0.3767	0.3251
	7	5	37.92	0.3413	0.4887		1	−3	50.75	0.3562	0.3327
							1	−1	51.52	0.3354	0.3406
			A: Full-Step Colors						A: Full-Step Colors		
	1	1	52.04	0.3143	0.3490		1	1	73.12	0.3143	0.3470
	1	3	52.24	0.2929	0.3578						
	1	5	52.11	0.2709	0.3672		3	−1	73.96	0.3540	0.3635
							3	1	74.76	0.3345	0.3722
	3	−5	50.43	0.4024	0.3489						
	3	−3	51.68	0.3810	0.3580		5	−1	75.09	0.3762	0.3873
	3	−1	52.66	0.3593	0.3675		5	1	76.07	0.3560	0.3974
	3	1	53.32	0.3372	0.3776						
	3	3	53.61	0.3147	0.3881				B: Half-Step Colors		
	5	−5	50.77	0.4293	0.3722	−1.5	−1.5	−1.5	21.72	0.3121	0.2958
	5	−3	52.27	0.4071	0.3828		−1.5	−0.5	21.86	0.2986	0.3000
	5	−1	53.47	0.3846	0.3940		−1.5	0.5	21.96	0.2849	0.3043
	5	1	54.30	0.3616	0.4059		−1.5	1.5	22.01	0.2712	0.3088
	5	3	54.69	0.3381	0.4187						
							−0.5	−1.5	22.16	0.3275	0.3139
	7	−5	50.71	0.4568	0.3945		−0.5	−0.5	22.34	0.3134	0.3188
	7	−3	52.46	0.4343	0.4067		−0.5	0.5	22.46	0.2991	0.3238
	7	−1	53.89	0.4110	0.4197		−0.5	1.5	22.53	0.2847	0.3290
	7	1	54.90	0.3874	0.4337						
	7	3	55.39	0.3632	0.4487		0.5	−1.5	22.56	0.3436	0.3323
							0.5	−0.5	22.77	0.3290	0.3378
	9	−5	50.24	0.4851	0.4150		0.5	0.5	22.93	0.3143	0.3435
	9	−3	52.21	0.4623	0.4290		0.5	1.5	23.02	0.2993	0.3495
	9	−1	53.88	0.4385	0.4442						
	9	1	55.08	0.4143	0.4603		1.5	−1.5	22.91	0.3606	0.3507
	9	3	55.68	0.3895	0.4777		1.5	−0.5	23.16	0.3455	0.3570
							1.5	0.5	23.35	0.3302	0.3636
	11	−3	51.56	0.4905	0.4492		1.5	1.5	23.46	0.3147	0.3704
	11	−1	53.43	0.4665	0.4665						
	11	1	54.81	0.4420	0.4850	−1	−2	−1	24.19	0.2988	0.2908
							−2	0	24.31	0.2861	0.2944
4	−2	−2	58.70	0.3124	0.2996		−2	1	24.38	0.2732	0.2983
	−2	0	59.18	0.2942	0.3054						
	−2	2	59.43	0.2758	0.3114		−1	−2	24.51	0.3261	0.3038
							−1	0	24.84	0.2995	0.3125
	0	−4	59.39	0.3520	0.3173		−1	2	24.97	0.2726	0.3216
	0	−2	60.26	0.3330	0.3240						
	0	0	60.89	0.3138	0.3310		0	−2	24.94	0.3414	0.3210
	0	2	61.24	0.2944	0.3383		0	−1	25.17	0.3277	0.3259
	0	4	61.29	0.2746	0.3460		0	0	25.35	0.3139	0.3309
							0	1	25.47	0.2999	0.3362
	2	−4	60.51	0.3750	0.3407		0	2	25.52	0.2858	0.3416
	2	−2	61.60	0.3551	0.3486						
	2	0	62.40	0.3350	0.3569		1	−2	25.32	0.3574	0.3383
	2	2	62.88	0.3146	0.3657		1	0	25.81	0.3290	0.3496
	2	4	62.98	0.2937	0.3750		1	2	26.03	0.2998	0.3618
	4	−4	61.30	0.3992	0.3638		2	−1	25.97	0.3595	0.3619
	4	−2	62.63	0.3785	0.3732		2	0	26.22	0.3448	0.3683
	4	0	63.63	0.3576	0.3830		2	1	26.39	0.3298	0.3751
	4	2	64.24	0.3363	0.3934						
	4	4	64.41	0.3145	0.4044	−0.5	−2.5	−0.5	26.63	0.2870	0.2856
							−2.5	0.5	26.72	0.2749	0.2891
	6	−4	61.70	0.4244	0.3863						
	6	−2	63.28	0.4031	0.3972		−1.5	−1.5	27.03	0.3123	0.2986
	6	0	64.50	0.3815	0.4086		−1.5	−0.5	27.19	0.2998	0.3026
	6	2	65.26	0.3594	0.4208		−1.5	0.5	27.31	0.2873	0.3066
							−1.5	1.5	27.37	0.2746	0.3107
	8	−2	63.51	0.4286	0.4203						
	8	0	64.94	0.4084	0.4335		−0.5	−2.5	27.28	0.3393	0.3109

TABLE 1 *Continued*

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}
	8	2	65.86	0.3838	0.4476		−0.5	−1.5	27.53	0.3264	0.3152
							−0.5	−0.5	27.73	0.3134	0.3198
	10	−2	63.27	0.4548	0.4420		−0.5	0.5	27.87	0.3003	0.3244
	10	0	64.92	0.4322	0.4571		−0.5	1.5	27.96	0.2871	0.3292
							−0.5	2.5	27.98	0.2738	0.3341
	12	0	64.45	0.4584	0.4788						
							0.5	−2.5	27.70	0.3544	0.3273
5	−1	−1	70.76	0.3132	0.3158		0.5	−1.5	27.99	0.3411	0.3322
	−1	1	71.24	0.2954	0.3220		0.5	−0.5	28.23	0.3277	0.3373
							0.5	0.5	28.40	0.3143	0.3424
	1	−1	72.49	0.3330	0.3396		0.5	1.5	28.51	0.3005	0.3479
							0.5	2.5	28.54	0.2866	0.3536
			B: Half Step Colors						B: Half Step Colors		
	1.5	−1.5	28.40	0.3565	0.3492		0.5	1.5	32.44	0.3017	0.3464
	1.5	−0.5	28.68	0.3427	0.3549		0.5	2.5	32.49	0.2890	0.3516
	1.5	0.5	28.88	0.3288	0.3608						
	1.5	1.5	29.01	0.3147	0.3668		1.5	−1.5	32.34	0.3529	0.3478
							1.5	−0.5	32.62	0.3403	0.3529
	2.5	−0.5	29.06	0.3584	0.3725		1.5	0.5	32.83	0.3275	0.3582
	2.5	0.5	29.30	0.3440	0.3791		1.5	1.5	32.97	0.3146	0.3637
0	−3	0	28.28	0.2765	0.2811		2.5	−0.5	33.03	0.3545	0.3691
							2.5	0.5	33.28	0.3414	0.3750
	−2	−1	28.75	0.3001	0.2938						
	−2	1	28.96	0.2764	0.3011	1	−2	−1	33.76	0.3011	0.2965
							−2	0	33.90	0.2901	0.2999
	−1	−2	29.09	0.3251	0.3059		−2	1	34.00	0.2791	0.3034
	−1	−1	29.29	0.3130	0.3099						
	−1	0	29.45	0.3007	0.3141		−1	−2	34.13	0.3243	0.3077
	−1	1	29.56	0.2884	0.3183		−1	0	34.52	0.3017	0.3154
	−1	2	29.61	0.2759	0.3226		−1	2	34.70	0.2787	0.3233
	0	−3	29.27	0.3516	0.3174		0	−2	34.65	0.3371	0.3225
	0	−1	29.81	0.3265	0.3263		0	−1	34.91	0.3255	0.3267
	0	1	30.13	0.3011	0.3358		0	0	35.11	0.3138	0.3310
	0	3	30.20	0.2750	0.3458		0	1	35.25	0.3020	0.3354
							0	2	35.33	0.2902	0.3398
	1	−2	29.99	0.3537	0.3378						
	1	−1	30.28	0.3407	0.3428		1	−2	35.12	0.3505	0.3373
	1	0	30.50	0.3277	0.3480		1	0	35.65	0.3266	0.3467
	1	1	30.66	0.3145	0.3534		1	2	35.93	0.3021	0.3567
	1	2	30.75	0.3011	0.3590						
							2	−1	35.87	0.3522	0.3573
	2	−1	30.69	0.3555	0.3594		2	0	36.15	0.3398	0.3626
	2	1	31.14	0.3285	0.3712		2	1	36.35	0.3273	0.3680
	3	0	31.34	0.3571	0.3823	1.5	−1.5	−1.5	37.40	0.3126	0.3032
							−1.5	−0.5	37.60	0.3018	0.3067
0.5	−2.5	−0.5	30.48	0.2891	0.2892		−1.5	0.5	37.74	0.2910	0.3102
	−2.5	0.5	30.58	0.2779	0.2925		−1.5	1.5	37.83	0.2801	0.3138
	−1.5	−1.5	30.89	0.3125	0.3012		−0.5	−1.5	38.00	0.3246	0.3176
	−1.5	−0.5	31.06	0.3009	0.3049		−0.5	−0.5	38.22	0.3135	0.3215
	−1.5	0.5	31.19	0.2894	0.3086		−0.5	0.5	38.39	0.3023	0.3254
	−1.5	1.5	31.26	0.2777	0.3125		−0.5	1.5	38.50	0.2911	0.3295
	−0.5	−2.5	31.17	0.3372	0.3125		0.5	−1.5	38.55	0.3370	0.3321
	−0.5	−1.5	31.42	0.3253	0.3166		0.5	−0.5	38.81	0.3257	0.3363
	−0.5	−0.5	31.62	0.3134	0.3207		0.5	0.5	39.01	0.3141	0.3408
	−0.5	0.5	31.77	0.3014	0.3250		0.5	1.5	39.14	0.3026	0.3453
	−0.5	1.5	31.87	0.2893	0.3294						
	−0.5	2.5	31.90	0.2771	0.3338		1.5	−1.5	39.05	0.3500	0.3466
							1.5	−0.5	39.35	0.3383	0.3514
	0.5	−2.5	31.62	0.3510	0.3276		1.5	0.5	39.58	0.3265	0.3563
	0.5	−1.5	31.91	0.3388	0.3321		1.5	1.5	39.74	0.3146	0.3613
	0.5	−0.5	32.14	0.3266	0.3367						
	0.5	0.5	32.32	0.3142	0.3416						

7. OSA-UCS Notations from CIE Coordinates

7.1 *OSA-UCS Color Space*—The three coordinates of the OSA Committee's color space are (*L, j, g*) standing for

lightness, yellowness-blueness, and greeness-redness, respectively (see Note 1.) The initial *j* (from the French word jaune, for yellow) is used to avoid confusion with the CIE chromaticity coordinate *y*. The quantity *L* was derived from the Committee's original lightness scale factor, Λ.

$$L = (\Lambda - 14.4)/\sqrt{2} \tag{1}$$

where:

$$\Lambda = 5.9[Y_0^{1/3} - 2/3 + 0.042(Y_0 - 30)^{1/3}] \tag{2}$$

is the modified Semmelroth **(4)** formula that takes crispening of color differences into account for a gray background of 30 % luminous reflectance. The quantity Y_0 in the equation for Λ is obtained from a modified Sanders-Wyszecki **(5)** formula:

$$Y_0 = Y(4.4934x^2 + 4.3034y^2 - 4.276xy - 1.3744x - 2.5643y + 1.8103) \tag{3}$$

where Y, x, y are the CIE 1964 color specifications of a given specimen. The usual subscript 10 has been omitted in the text and equations for clarity, but should be assumed to apply to all chromaticity coordinates and tristimulus values. The calculated value of Y_0 refers to the tristimulus value *Y* of a gray specimen that appears equally light to a non-gray object-color stimulus (*Y, x, y*). The perfect reflecting diffuser illuminated by CIE standard illuminant D_{65} yields the white specimen with $Y = 100$. The formula for Y_0 is a chromatic enhancement of lightness.

7.1.1 The coordinates *j* and *g* are defined by the equations:

$$j = C(1.7R^{1/3} + 8G^{1/3} - 9.7B^{1/3}) \tag{4}$$

$$g = C(-13.7R^{1/3} + 17.7G^{1/3} - 4B^{1/3})$$

where:

$$C = \frac{\Lambda}{5.9(Y_0^{1/3} - 2/3)} = 1 + 0.042\,\frac{(Y_0 - 30)^{1/3}}{Y_0^{1/3} - 2/3} \tag{5}$$

$$R = 0.799X + 0.4194Y - 0.1648Z \tag{6}$$

$$G = -0.4493X + 1.3265Y + 0.0927Z$$

$$B = -0.1149X + 0.3394Y + 0.717Z$$

7.1.2 The (*R, G, B*) tristimulus values refer to a fundamental system of primary stimuli whose (*x, y*) chromaticity coordinates are given as:

$$x(R) = 0.747 \qquad y(R) = 0.253 \tag{7}$$

$$x(G) = 2.92 \qquad y(G) = -4.54$$

$$x(B) = 0.171 \qquad y(B) = 0$$

Note that when, as is often the case, the available data are in the form *Y, x, y,* the other tristimulus values can be obtained from:

$$X = \frac{xY}{y} \text{ and } Z = \frac{(1 - x - y)Y}{y} \tag{8}$$

7.2 *OSA Hue and Chroma*—It is convenient to define new terms, analogous to those used in other systems such as Munsell and CIE 1976, as follows:

7.2.1 *OSA Hue Angle or Hue*:

$$h_{OSA} = \tan^{-1} g/j \tag{9}$$

where h_{OSA} lies between 0 and 90° if *g* and *j* are both positive, between 90 and 180° if *g* is positive and *j* is negative, between 180 and 270° if *g* and *j* are both negative, and between 270 and 360° if *g* is negative and *j* is positive.

7.2.2 *OSA Chroma*:

$$c_{OSA} = (j^2 + g^2)^{1/2} \tag{10}$$

7.2.3 **Warning:** Interpret OSA hue and chroma in visual terms cautiously, since the OSA-UCS system was not designed to include these concepts.

8. OSA-UCS Notations by Visual Means

8.1 *Lighting and Viewing Conditions*:

8.1.1 *Observers*—The specimens should be viewed by observers with normal color vision.

8.1.2 *Use of Natural Daylight*—Place the specimen on a neutral background with 30 % reflectance, equivalent to (0,0,0) and illuminate it with natural daylight. Select a window in which the sun is not shining. A north window is usually chosen in the northern hemisphere. Place a table by the window so that light reaches the table top from the observer's side, chiefly from the sky, and at angles centering on 45° from the horizontal. Place a canopy of black cloth above the working surface to prevent errors caused by reflections of light from the ceiling or room objects in the surface of the specimen. View the specimen along a direction just far enough from the perpendicular to avoid reflection of the observer's forehead. The directions of illumination and viewing may be reversed with equivalent results. When using reverse conditions, namely, illumination along the normal and viewing at 45° from the normal, a black cloth should be hung opposite to the observer to avoid extraneous reflections being seen on the surfaces of the test specimens.

8.1.3 *Use of Artificial Daylight*—A standard color-matching viewing booth with daylight-quality illumination (see Practice D 1535 and Practice D 1729) may be used. The provisions of 8.1.2 should be followed in other respects.

8.2 *Determining the OSA-UCS Notation*:

8.2.1 *Display of Specimens*—To visually determine the OSA-UCS notation for an object-color test specimen, locate the OSA-UCS atlas samples that surround the test specimen in OSA-UCS space and interpolate among them to estimate the correct notation. The larger the number of OSA-UCS samples available, the more accurate the estimate will be. Since there are only 420 full step color samples in the current atlas, accuracy is limited. Around the neutral axis 134 half-step samples have been added, making the placement of grayer colors easier and more accurate.

NOTE 2—In the OSA-UCS atlas, samples are arranged numerically by the first coordinate, *L*, representing lightness, in the three coordinate notation. Within each lightness level, samples are arranged in horizontal rows across the page by the second coordinate, *j*, and lastly by the third coordinate, *g*. Negative numbers precede positive numbers in each case. The atlas begins with the darkest colors, $L = -7$, and continues through the middle lightness, $L = 0$, up to the lightest colors, $L = 5$. OSA-UCS atlases may be rearranged to place similar colors close to one another, making it easier to locate samples visually. See Appendix X2.

8.2.1.1 Locate the atlas page(s) containing samples with lightness closest to the lightness of the specimen. Select from among them the atlas sample that most closely resembles the test specimen in appearance. Compare the test specimen with

the atlas sample either by placing the two colors edge to edge or, if this is not possible, by using a mask that matches the central gray, (0,0,0), to isolate equal areas of the specimen and the sample(s) being compared.

8.2.1.2 If the colors can be placed side by side, examine the lightness of the test specimen by judging the distinctness of the edge or border between the two colors **(6).** The line of demarcation between the colors will appear minimally distinct, even if the chromaticness of the colors is quite different, when their lightness is the same or very similar. Conversely, if the demarcation is distinct there is a large lightness difference.

8.2.2 *Lightness*—To estimate the lightness difference between the test specimen and the selected atlas sample, choose from the atlas a second sample, also similar in chromaticness to the test specimen, from either the next lighter or darker OSA-UCS level, depending on whether the test specimen is lighter or darker than the first atlas sample selected. Note that if the test specimen has the same chromaticness as the atlas sample, it is necessary to go up or down two units of L in the atlas to find a second sample with the same chromaticness.

8.2.2.1 Place the test specimen between the two samples. Ignoring differences in chromaticness, assign to the test specimen a lightness number that best represents the lightness position of the specimen in relation to the lightness of the two OSA-UCS atlas samples. Estimate the lightness difference to the nearest 0.2 unit of L, that is, to 0.2 of the interval between samples located on adjacent lightness levels, or 0.1 of the difference in lightness between atlas samples selected from lightness planes two units of L apart.

8.2.3 *Chromaticness*—The second and third coordinates in the notation for an OSA-UCS sample, taken together, indicate its chromaticness, a combination of its OSA hue and OSA chroma. To determine what the differences in chromaticness are between the test specimen and the most nearly similar atlas sample, select a third atlas sample with the same chromaticness, j and g, as that of the first atlas sample selected, but either lighter or darker, as appropriate. It will be necessary to move two lightness levels to find an atlas sample with the same chromaticness.

8.2.3.1 Place the test specimen between the two selected atlas samples. Chromaticness differences between the test specimen and the atlas samples should be recognizable. If the three colors make a perceptually smooth or uniform color sequence with only a lightness difference among them, assign the test specimen the same values of j and g as the atlas samples. If the test specimen looks out of place between the atlas samples, note whether it exhibits a hue difference, or appears either grayer or more chromatic than the atlas samples, or differs from the atlas samples by a combination of both hue and chroma.

8.2.3.2 If a chromaticness difference is seen, locate the nearest atlas sample in the appropriate direction and replace the second atlas sample with this one. It may be necessary to try several samples until one is found that forms a uniform visual sequence with the test specimen and the first atlas sample. If the direction of chromatic difference is not obvious, estimate the direction of hue difference from the test specimen and choose an atlas sample with an OSA hue difference in the estimated direction. Place the test specimen between the two atlas samples and if the test specimen looks too gray or has too much chroma, replace the second atlas sample with one of the same OSA hue but having lower or higher OSA chroma, as appropriate. Table 2 lists the OSA chromas for OSA-UCS notations. Table 3 lists the OSA-UCS notations with the same OSA hue.

8.2.3.3 Once the two atlas samples are found that most closely approximate the appearance of the specimen and, when placed on each side of it, form a perceptually uniform sequence, interpolate between the values of j and g of the two atlas samples to complete the notation for the specimen. Estimate the difference to the nearest fifth of the 2-unit difference between atlas samples having one-step differences in j or g, that is, to the nearest 0.4 unit of j or g. See Appendix X3 for an example.

9. Report

9.1 Report the following information:

9.1.1 Report the notation of the test specimen in OSA-UCS (L, j, g) coordinates, specifying whether this notation was obtained visually from the OSA-UCS atlas samples or by conversion of colorimetric data.

10. Precision and Bias

10.1 The precision and bias of the computational method are determined by the precision and bias of the tristimulus data

TABLE 2 OSA-UCS Chroma, $(j^2 + g^2)^{1/2}$

j or g	g or j	Chroma	j or g	g or j	Chroma
0	0	0	2	8	8.25
0	0.5	0.50	2	9	9.22
0	1	1.00	2	10	10.20
0	2	2.00	2	11	11.18
0	3	3.00	3	3	4.24
0	4	4.00	3	4	5.00
0	5	5.00	3	5	5.83
0	6	6.00	3	6	6.71
0	7	7.00	3	7	7.62
0	8	8.00	3	8	8.54
0	9	9.00	3	9	9.49
0	10	10.00	3	10	10.44
0	11	11.00	3	11	11.40
0	12	12.00	4	4	5.66
0.5	0.5	0.71	4	5	6.40
0.5	1	1.12	4	6	7.21
0.5	1.5	1.58	4	7	8.06
1	1	1.41	4	8	8.94
1	2	2.24	4	9	9.85
1	3	3.16	4	10	10.77
1	4	4.12	5	5	7.07
1	5	5.10	5	6	7.81
1	6	6.08	5	7	8.60
1	7	7.07	5	8	9.43
1	8	8.06	5	9	10.30
1	9	9.06	6	6	8.49
1	10	10.05	6	7	9.22
1	11	11.05	6	8	10.00
1	12	12.04	6	9	10.82
1.5	1	1.80	7	7	9.90
1.5	1.5	2.12	7	8	10.63
2	2	2.83	7	9	11.40
2	3	3.61	8	8	11.31
2	4	4.47			
2	5	5.39			
2	6	6.32			
2	7	7.28			

used; see Practice E 308 and Practice E 1164 for an indication of what this may be. Any additional contribution due to the calculations of this method should be negligible.

10.2 The precision and bias of the visual method will be determined.

TABLE 3

h_{OSA},°	Equation of Hue Line	*L, j, g* of Atlas Samples
		Yellow to Green Quadrant
360, 0[A]	j > 0, g = 0	4,2,0; 4,4,0; 4,6,0; 4,8,0; 4,10,0; 4,12,0; 2,2,0; 2,4,0; 2,6,0; 2,8,0; 2,10,0; 1,1,0; 1,2,0; 0.1,0; 0,2,0; 0,3,0; 0,4,0; 0,6,0; 0,8,0; − 1,1,0; − 1,2,0; − 2,2,0; − 2,4,0; − 2, 6,0; − 4,2,0; − 4,4,0; − 6,2,0
5	j − 11g = 0	3,11,1
6	j − 9g = 0	3,9,1; 1,9,1
8	j − 7g = 0	3,7,1; 1,7,1; − 1,7,1
11	j − 5g = 0	5,5,1; 3,5,1; 2,10,2; 1.5,1; 0.5,2.5,0.5; − 0.5,2.5,0.5; − 1,5,1; − 3,5,1
14	j − 4g = 0	4,8,2; 2,8,2; 0,8,2
18	j − 3g = 0	5,3,1; 4,6,2; 3,3,1; 3,9,3; 2,6,2; 1.5,1.5,0.5; 1,3,1; 1,9,3; 0.5,1.5,0.5; 0,6,2; − 0.5,1.5,0.5; − 1,3,1; − 1.5,1.5,0.5; − 2,6,2; − 3,3,1; − 5,3,1
23	3j − 7g = 0	3,7,3; 1,7,3; − 1,7,3;
27	j − 2g = 0	4,4,2; 2,4,2; 2,8,4; 1,2,1; 0,2,1; 0,4,2; 0,8,4; − 1,2,1; − 2,4,2; − 4,4,2
31	3j − 5g = 0	3,5,3; 1,5,3; − 1,5,3; − 3,5,3
34	2j − 3g = 0	2,6,4; 0,6,4; − 2,6,4
36	5j − 7g = 0	1,7,5; − 1,7,5
45	j − g = 0	5,1,1; 4,4,4; 4,2,2; 3,1,1; 3,3,3; 2,2,2; 2,4,4; 1.5,0.5,0.5; 1.5,1.5,1.5; 1,1,1; 1,3,3; 1,5,5; 0.5,0.5,0.5; 0.5,1.5,1.5; 0,1,1; 0,2,2; 0,4,4; − 0.5,0.5,0.5; − 0.5,1.5,1.5; − 1,1,1; − 1,3,3; − 1,5,5; − 1.5,0.5,0.5; − 1.5,1.5,1.5; − 2,2,2; − 2,4,4; − 3,1,1; − 3,3,3; − 3,5,5; − 4,2,2; − 4,4
56	3j − 2g = 0	0,4,6
59	5j − 3g = 0	1,3,5; − 1,3,5; − 3,3,5
63	2j − g = 0	4,2,4; 2,2,4; 1,1,2; 0,1,2; 0,2,4; − 1,1,2; − 2,2,4; − 4,2,4
72	3j − g = 0	3,1,3; 2,2,6; 1.5,0.5,1.5; 1,1,3; 0.5,0.5,1.5; 0,2,6; − 0.5,0.5,1.5; − 1,1,3; − 1.5,0.5,1.5; − 2,2,6; − 3,1,3; − 5,1,3
79	5j − g = 0	3,1,5; 1,1,5; 0.5,0.5,2.5; − 0.5,0.5,2.5; − 1,1,5; − 3,1,5
		Green to Blue Quadrant
90	j = 0, g > 0	4,0,2; 4,0,4; 2,0,2; 2,0,4; 2,0,6; 1,0,1; 1,0,2; 0,0,1; 0,0,2; 0,0,3; 0,0,4; 0,0,6; − 1,0,1; − 1,0,2; − 2,0,2; − 2,0,4; − 2,0,6; − 4,0,2; − 4,0,4; − 6,0,2
101	5j + g = 0	1,−1,5; 0.5,−0.5,2.5; − 0.5,−0.5,2.5; − 1,−1,5; − 3,−1,5
108	3j + g = 0	3,−1,3; 1.5,−0.5,1.5; 1,−1,3; 0.5,−0.5,1.5; − 0.5,−0.5,1.5; − 1,−1,3; − 1.5,−0.5,1.5; − 2,−2,6; − 3,−1,3; − 5,−1,3
117	2j + g = 0	2,−2,4; 1,−1,2; 0,−1,2; 0,−2,4; − 1,−1,2; − 2,−2,4; − 4,−2,4
121	5j + 3g = 0	1,−3,5; − 1,−3,5; − 3,−3,5
135	j + g = 0	5,−1,1; 4,−2,2; 3,−1,1; 3,−3,3; 2,−2,2; 2,−4,4; 1.5,−0.5,0.5; 1.5,−1.5,1.5; 1,−1,1; 1,−3,3; 0.5,−0.5,0.5; 0.5,−1.5,1.5; 0,−1,1; 0,−2,2; 0,−4,4; − 0.5,−0.5,0.5; − 0.5,−1.5,1.5; − 1,−1,1; − 1,−3,3; − 1.5,−0.5,0.5; − 1.5,−1.5,1.5; − 2,−2,2; − 2,−4,4; − 3,−1,1; − 3,−3,3; − 4,−2,2; − 4,−
149	3j + 5g = 0	1,−5,3; − 1,−5,3; − 3,−5,3; − 5,−5,3
153	j + 2g = 0	2,−4,2; 1,−2,1; 0,−2,1; 0,−4,2; − 1,−2,1; − 2,−4,2; − 4,−4,2; − 6,−4,2
162	j + 3g = 0	3,−3,1; 1.5,−1.5,0.5; 1,−3,1; 0.5,−1.5,0.5; 0,−6,2; − 0.5,−1.5,0.5; − 1,−3,1; − 1.5,−1.5,0.5; − 2,−6,2; − 3,−3,1; − 5,−3,1; − 7,−3,1
169	j + 5g = 0	1,−5,1; 0.5,−2.5,0.5; − 0.5,−2.5,0.5; − 1,−5,1; − 3,−5,1; − 5,−5,1
		Blue to Red Quadrant
180	j< 0, g = 0	4,−2,0; 2,−2,0; 2,−4,0; 1,−1,0; 1,−2,0; 0,−1,0; 0,−2,0; 0,−3,0; 0,−4,0; 0,−6,0; − 1,−1,0; − 1,−2,0; − 2,−2,0; − 2,−4,0; − 2,−6,0; − 4,−2,0; − 4,−4,0; − 6,−2,0; − 6,−4,0
191	j − 5g = 0	0.5,−2.5,−0.5; − 0.5,−2.5,−0.5; − 1,−5,−1; − 3,−5,−1; − 5,−5,−1
198	j − 3g = 0	3,−3,−1; 1.5,−1.5,−0.5; 1,−3,−1; 0.5,−1.5,−0.5; − 0.5,−1.5,−0.5; − 1,−3,−1; − 1.5,−1.5,−0.5; − 3,−3,−1; − 5,−3,−1; − 7,−3,−1
207	j − 2g = 0	1,−2,−1; 0,−2,−1; 0,−4,−2; − 1,−2,−1; − 2,−4,−2; − 4,−4,−2; − 6,−4,−2
225	j − g = 0	5,−1,−1; 4,−2,−2; 3,−1,−1; 2,−2,−2; 1.5,−0.5,−0.5; 1.5,−1.5,−1.5; 1,−1,−1; 1,−3,−3; 0.5,−0.5,−0.5; 0.5,−1.5,−1.5; 0,−1,−1; 0,−2,−2; − 0.5,−0.5,−0.5; − 0.5,−1.5,−1.5; − 1,−1,−1; − 1,−3,−3; − 1.5,−0.5,−0.5; − 1.5,−1.5,−1.5; − 2,−2,−2; − 3,−1,−1; − 3,−3,−3; − 4,−2,−2; −
239	5j − 3g = 0	−3,−3,−5
243	2j − g = 0	2,−2,−4; 1,−1,−2; 0,−1,−2; 0,−2,−4; − 1,−1,−2; − 2,−2,−4; − 4,−2,−4; − 6,−2,−4
252	3j − g = 0	3,−1,−3; 1.5,−0.5,−1.5; 1,−1,−3; 0.5,−0.5,−1.5; − 0.5,−0.5,−1.5; − 1,−1,−3; − 1.5,−0.5,−1.5; − 2,−2,−6; − 3,−1,−3; − 5,−1,−3
259	5j − g = 0	3,−1,−5; 1,−1,−5; 0.5,−0.5,−2.5; − 0.5,−0.5,−2.5; − 1,−1,−5; − 3,−1,−5; − 5,−1,−5
262	7j − g = 0	−1,−1,−7; − 3,−1,−7
		Red to Yellow Quadrant
270	j = 0, g < 0	4,0,−2; 4,0,−4; 2,0,−2; 2,0,−4; 2,0,−6; 1,0,−1; 1,0,−2; 0,0,−1; 0,0,−2; 0,0,−3; 0,0,−4; 0,0,−6; 0,0,−8; − 1,0,−1; − 1,0,−2; − 2,0,−2; − 2,0,−4; − 2,0,−6; − 2,0,−8; − 2,0,−10; − 4,0,−2; − 4,0,−4; − 4,0,−6; − 6,0,−2; − 6,0,−4; − 6,0,−6
276	9j + g = 0	−1,1,−9; − 3,1,−9
278	7j + g = 0	1,1,−7; − 1,1,−7; − 3,1,−7; − 5,1,−7
281	5j + g = 0	3,1,−5; 1,1,−5; 0.5,0.5,−2.5; − 0.5,0.5,−2.5; − 1,1,−5; − 2,2,−10; − 3,1,−5; − 5,1,−5
284	4j + g = 0	0,2,−8; − 2,2,−8; − 4,2,−8
288	3j + g = 0	3,1,−3; 2,2,−6; 1.5,0.5;−1.5; 1,1,−3; 1,3,−9; 0.5,0.5,−1.5; 0,2,−6; − 0.5,0.5,−1.5; − 1,1,−3; − 1,3,−9; − 1.5,0.5,−1.5; − 2,2,−6; − 3,1,−3; − 3,3,−9; − 4,2,−6; − 5,1,−3; − 6,2,−6
292	5j + 2g = 0	−2,4,−10
293	7j + 3g = 0	1,3,−7; − 1,3,−7; − 3,3,−7; − 5,3,−7

TABLE 3 *Continued*

h_{OSA},°	Equation of Hue Line	*L, j, g* of Atlas Samples
297	2j + g = 0	4,2,−4; 2,2,−4; 1,1,−2; 0,1,−2; 0,2,−4; 0,4,−8; − 1,1,−2; − 2,2,−4; − 2,4,−8; − 4,2,−4; − 4,4,−8; − 6,2,−4
299	9j + 5g = 0	−1,5,−9
301	5j + 3g = 0	3,3,−5; 1,3,−5; − 1,3,−5; − 2,6,−10; − 3,3,−5; − 5,3,−5
304	3j + 2g = 0	2,4,−6; 0,4,−6; − 2,4,−6; − 4,4,−6
306	7j + 3g = 0	1,5,−7; − 1,5,−7; − 3,5,−7
307	4j + 3g = 0	0,6,−8; − 2,6,−8
308	9j + 7g = 0	−1,7,−9
315	j + g = 0	5,1,−1; 4,2,−2; 4,4,−4; 3,1,−1; 3,3,−3; 3,5,−5; 2,2,−2; 2,4,−4; 2,6,−6; 1.5,0.5,−0.5; 1.5,1.5,−1.5; 1,1,−1; 1,3,−3; 1,5,−5; 1,7,−7; 0.5,0.5,−0.5; 0.5,1.5,−1.5; 0,1,−1; 0,2,−2; 0,4,−4; 0,6,−6; 0,8,−8; − 0.5,0.5,−0.5; − 0.5,1.5,−1.5; − 1,1,−1; − 1,3,−3; − 1,5,−5; − 1,7,−7; − 1.5,0.5,−0.5; − 1.5,1.5,−1.5; − 2,2,−2; − 2,4,−4; − 2,6,−6; − 3,1,
322	7j + 9g = 0	1,9,−7
323	3j + 4g = 0	2,8,−6; 0,8,−6
324	5j + 7g = 0	3,7,−5; 1,7,−5; − 1,7,−5
326	2j + 3g = 0	4,6,−4; 2,6,−4; 0,6,−4; − 2,6,−4
329	3j + 5g = 0	3,5,−3; 2,10,−6; 1,5,−3; − 1,5,−3; − 3,5,−3
331	5j + 9g = 0	3,9,−5; 1,9,−5
333	j + 2g = 0	4,4,−2; 2,4,−2; 2,8,−4; 1,2,−1; 0,2,−1; 0,4,−2; 0,8,−4; − 1,2,−1; − 2,4,−2; − 4,4,−2
337	3j + 7g = 0	3,7,−3; 1,7,−3; − 1,7,−3
338	2j + 5g = 0	2,10,−4
342	j + 3g = 0	5,3,−1; 4,6,−2; 3,3,−1; 3,9,−3; 2,6,−2; 1.5,1.5,−0.5; 1.3,−1; 1,9,−3; 0.5,1.5,−0.5; 0,6,−2; − 0.5,1.5,−0.5; − 1,3,−1; − 1.5,1.5,−0.5; − 2,6,−2; − 3,3,−1; − 5,3,−1
345	3j + 11g = 0	3,11,−3
346	j + 4g = 0	4,8,−2; 2,8,−2; 0,8,−2
349	j + 5g = 0	5,5,−1; 4,10,−2; 3,5,−1; 2,10,−2; 1,5,−1; 0.5,2.5,−0.5; − 0.5,2.5,−0.5; − 1,5,−1; − 3,5,−1
352	j + 7g = 0	3,7,−1; 1,7,−1; − 1,7,−1
354	j + 9g = 0	3,9,−1; 1,9,−1
355	j + 11g = 0	3,11,−1

[A] Hue angles of 0 and 360° represent, on a closed hue circle, the same color, in this case yellow. $h_{OSA} = 0$ *does not* represent" no hue" or the absence of hue.

11. Keywords

11.1 color; Optical Society of America; Optical Society of America Uniform Color Scales; OSA-UCS; Uniform Color Scales

APPENDIXES

(Nonmandatory Information)

X1. DESCRIPTION OF OSA-UCS SYSTEM

X1.1 A set of OSA-UCS samples is available in atlas form from the Optical Society of America[4]. The painted samples contained in the atlas closely represent, when viewed by observers with normal color vision under daylight illumination (D_{65}) and on a gray surround of 30 % luminous reflectance, the colors of the OSA-UCS as specified by the CIE 1964 *X Y Z* color coordinates for standard illuminant D_{65} given in Table 1.

X1.2 All colors of medium lightness (approximately 30 % luminous reflectance) are represented by points on the square lattice of the horizontal plane $L = 0$. The planes parallel to and above $L = 0$ are denoted by $L = 1$, $L = 2$, etc. The planes parallel to and below $L = 0$ are denoted by $L = -1$, $L = -2$, etc. There are only a few points on the planes $L = 5$ and $L = -7$ representing colors that are reproducible by stable paint mixtures.

X1.3 In each plane of constant lightness (L), lattice coordinates (j, g) are used to identify the lattice points. Both j and g are zero for grays. The coordinates j and g are points on two axes perpendicular to one another on a constant-lightness plane. One of these axes, j, passes from yellow through the central gray to blue, while the other axis, g, passes from green through the central gray to red. The yellow half of one axis of the lightness plane consists of increasing positive values of j coupled with zero values of g. The blue half of that axis is indicated by negative values of j with zero values of g. The green half of the second axis has positive values of g with zero values of j. The red half of the second axis consists of negative values of g with zero values of j. See Fig. 1. The yellow direction (j) closely approximates the hue usually represented as unique yellow. The $-j$, $g$and $-$ g axes represent general hue directions and not unique blue, green or red (see Note 1).

X1.4 In this atlas, the values of L, j, g for each sample are either all even or all odd integers. The integer L, j, g may be either positive, zero or negative, in all combinations, but for any one sample all three integers must be all odd or all even, where zero is considered even.

X1.5 There are seven main families of cleavage planes through the OSA-UCS color solid **(3, 7, 8)**. See Fig. 2.

X1.5.1 Horizontal cleavage planes are obtained by cutting through the lattice space at a constant level of lightness. The family of horizontal cleavage planes is described by the equation:

$$L = \text{constant}$$

where the value of the constant in the OSA-UCS atlas ranges in whole numbers from − 7 to + 5, for a total of 13 constant-lightness planes.

X1.5.2 There are two families of vertical cleavage planes at 90° to each other and 45° from the *j* and *g* axes. The equations that describe these 25 planes are:

$$j - g = \text{constant (range of constant from } -8 \text{ to } +16) \quad \text{(X1.1)}$$
$$j + g = \text{(range of constant from } -10 \text{ to } +12)$$

X1.5.3 The third main type of cleavage plane in the OSA-UCS atlas consists of four families of oblique planes, totaling 45 planes described by the equations:

$$L - j = \text{constant (range of constant from } -8 \text{ to } +6) \quad \text{(X1.2)}$$
$$L + j = \text{constant (range of constant from } -10 \text{ to } +16)$$
$$L - g = \text{constant (range of constant from } -8 \text{ to } +10) \quad \text{(X1.3)}$$
$$L + g = \text{constant (range of constant from } -12 \text{ to } +8)$$

Fig. 1 and Fig. 2 illustrate one horizontal, one vertical, and one oblique plane as examples.

X1.5.4 The seven families of planes described above display all the color sequences in which there is 2-unit spacing between samples. In addition, there are many other interesting families of planes. An example is a second pair of families of vertical planes placed at 90° to one another along the *j* and *g* axes. They are composed of 36 planes described by the equations:

$$j = \text{constant (range of constant from } -6 \text{ to } +12) \quad \text{(X1.4)}$$
$$g = \text{constant (range of constant from } -10 \text{ to } +6)$$

It should be kept in mind that there are no planes on which all color differences between nearest neighbors are equal.

X1.6 To illustrate the relationship of the OSA−UCS lightness planes to the CIE system, Fig. 3 shows the *j, g* coordinates of lightness plane $L = 0$ plotted on CIE 1964 (x, y) chromaticity diagram.

X1.7 For further information on the OSA-UCS system, see References **1, 3,** and **8** and over 30 additional articles cited in Reference **9**.

X2. ALTERNATIVE ARRANGEMENT OF OSA ATLAS SAMPLES

X2.1 The original arrangement of OSA-UCS atlas samples, described in Note 2, does not place samples of similar colors near one another. This appendix describes an alternative arrangement accomplishing that objective. In the new arrangement, the samples are placed on horizontal planes of constant lightness, beginning with the lightest such plane in the system, $L = 5$, and continuing through the color solid to the darkest level, $L = -7$.

X2.2 The samples on each of these horizontal planes lie at the intersections of a square grid formed by lines of constant *j*or *g*. The distances between samples along the grid lines is 2 UCS units of color difference. The spacing between horizontal planes is $-2 = 1.414$ UCS units; however, since samples fall over one another only on every other horizontal plane, the spacing between samples with the same values of *j* and *g* is $2-2 = 2.828$ UCS units.

X2.3 Since most horizontal planes contain more samples than can be stored in the pockets on one 8½ × 11-in. plastic sheet, such planes are divided into four quadrants. The green-to-blue quadrant always appears on the first of the four sheets for the selected lightness level; this is the *top left* position. The blue-to-red quadrant (*bottom left*) appears on the second sheet; the yellow-to-green (*top right*) on the third; and the red-to-yellow (*bottom right*) on the fourth. If there are no samples in a given quadrant, the corresponding sheet is omitted but the order of the remaining sheets for this lightness level is retained. Only a single sheet is used if all the samples on that horizontal plane fit onto one sheet.

X2.3.1 Table X2.1 lists the positions, by sheet, of the 558 samples in the OSA-UCS atlas, following the above conventions.

X2.4 By removing from the atlas the transparent plastic sheets for a single horizontal plane and laying them out in the order described, the entire plane can be seen. Lines can be drawn on the backing sheets behind the samples to indicate the $\pm j$ and $\pm g$ axes. However, to approximate the conditions of viewing used when the spacing of the samples was determined, the samples should be removed from the plastic sheets and placed on a gray background with color similar to that of the 0,0,0 sample.

NOTE X2.1—This arrangement is consistent with the definition of OSA hue angle given in 7.2.1.

X2.5 Following the atlas section including the *whole-step* samples (at UCS unit distances of 2), there is a section containing *half-step* samples. These samples fit in between the whole-step samples in regions near the neutral, $L = j = g = 0$, center point of the OSA-UCS solid. This increases the number of samples in the useful grayish region of the solid. In this region, combining the whole-step and half-step samples provides colors separated at distances of 1 UCS unit on the horizontal planes.

X2.6 *Instructions for Rearranging the Samples:*

X2.6.1 Remove the samples from the pockets of the vinyl plastic sheets in which they were furnished, and carefully polish each sample with a soft cloth to remove any plasticizer that has exuded from the vinyl onto the sample surfaces.

TABLE X2.1 Alternative Arrangement of OSA-UCS Samples on Atlas Pages

Part A. Whole-step Samples

L	Left Page No.	Position	*L, j, g* of Samples On							Right Page No.
			Left or Single Page				Right Page			
5	1	Single	5, − 1, 1;	5, 1, 1;	5, 3, 1;	5, 5, 1				
			5, − 1, − 1;	5, 1, − 1;	5, 3, − 1;	5, 5, − 1				
4	2	Top		4, 0, 4;	4, 2, 4;	4, 4, 4				3
			4, − 2, 2;	4, 0, 2;	4, 2, 2;	4, 4, 2	4, 6, 2;	4, 8, 2		
			4, − 2, 0;	4, 0, 0;	4, 2, 0;	4, 4, 0	4, 6, 0;	4, 8, 0;	4, 10, 0; 4, 12, 0	
			4, − 2, − 2;	4, 0, − 2;	4, 2, − 2;	4, 4, − 2	4, 6, − 2;	4, 8, − 2;	4, 10, − 2	
				4, 0, − 4;	4, 2, − 4;	4, 4, − 4	4, 6, − 4			
3	4	Top			3, 1, 5					6
			3, − 3, 3;	3, − 1, 3;	3, 1, 3;	3, 3, 3	3, 5, 3;	3, 7, 3;	3, 9, 3	
			3, − 3, 1;	3, − 1, 1;	3, 1, 1;	3, 3, 1	3, 5, 1;	3, 7, 1;	3, 9, 1; 3, 11, 1	
			3, − 3, − 1;	3, − 1, − 1;	3, 1, − 1;	3, 3, − 1	3, 5, − 1;	3, 7, − 1;	3, 9, − 1; 3, 11, − 1	
	5	Bottom		3, − 1, − 3;	3, 1, − 3;	3, 3, − 3	3, 5, − 3;	3, 7, − 3;	3, 9, − 3; 3, 11, − 3	7
				3, − 1, − 5;	3, 1, − 5;	3, 3, − 5	3, 5, − 5;	3, 7, − 5;	3, 9, − 5	
2	8	Top			2, 0, 6;	2, 2, 6				10
			2, − 4, 4;	2, − 2, 4;	2, 0, 4;	2, 2, 4	2, 4, 4;	2, 6, 4;	2, 8, 4	
			2, − 4, 2;	2, − 2, 2;	2, 0, 2;	2, 2, 2	2, 4, 2;	2, 6, 2;	2, 8, 2; 2, 10, 2	
			2, − 4, 0;	2, − 2, 0;	2, 0, 0;	2, 2, 0	2, 4, 0;	2, 6, 0;	2, 8, 0; 2, 10, 0	
				2, − 2, − 2;	2, 0, − 2;	2, 2, − 2	2, 4, − 2;	2, 6, − 2;	2, 8, − 2; 2, 10, − 2	
	9	Bottom		2, − 2, − 4;	2, 0, − 4;	2, 2, − 4	2, 4, − 4;	2, 6, − 4;	2, 8, − 4; 2, 10, − 4	11
					2, 0, − 6;	2, 2, − 6	2, 4, − 6;	2, 6, − 6;	2, 8, − 6; 2, 10, − 6	
1	12	Top		1, − 3, 5;	1, − 1, 5;	1, 1, 5	1, 3, 5;	1, 5, 5;	1, 7, 5	14
			1, − 5, 3;	1, − 3, 3;	1, − 1, 3;	1, 1, 3	1, 3, 3;	1, 5, 3;	1, 7, 3; 1, 9, 3	
			1, − 5, 1;	1, − 3, 1;	1, − 1, 1;	1, 1, 1	1, 3, 1;	1, 5, 1;	1, 7, 1; 1, 9, 1	
				1, − 3, − 1;	1, − 1, − 1;	1, 1, − 1	1, 3, − 1;	1, 5, − 1;	1, 7, − 1; 1, 9, − 1	
				1, − 3, − 3;	1, − 1, − 3;	1, 1, − 3	1, 3, − 3;	1, 5, − 3;	1, 7, − 3; 1, 9, − 3	
	13	Bottom			1, − 1, − 5;	1, 1, − 5	1, 3, − 5;	1, 5, − 5;	1, 7, − 5; 1, 9, − 5	15
						1, 1, − 7	1, 3, − 7;	1, 5, − 7;	1, 7, − 7; 1, 9, − 7	
							1, 3, − 9			
0	16	Top				0, 0, 6	0, 2, 6;	0, 4, 6		18
				0, − 4, 4;	0, − 2, 4;	0, 0, 4	0, 2, 4;	0, 4, 4;	0, 6, 4; 0, 8, 4	
			0, − 6, 2;	0, − 4, 2;	0, − 2, 2;	0, 0, 2	0, 2, 2;	0, 4, 2;	0, 6, 2; 0, 8, 2	
			0, − 6, 0;	0, − 4, 0;	0, − 2, 0;	0, 0, 0	0, 2, 0;	0, 4, 0;	0, 6, 0; 0, 8, 0	
				0, − 4, − 2;	0, − 2, − 2;	0, 0, − 2	0, 2, − 2;	0, 4, − 2;	0, 6, − 2; 0, 8, − 2	
	17	Bottom			0, − 2, − 4;	0, 0, − 4	0, 2, − 4;	0, 4, − 4;	0, 6, − 4; 0, 8, − 4	19
						0, 0, − 6	0, 2, − 6;	0, 4, − 6;	0, 6, − 6; 0, 8, − 6	
						0, 0, − 8	0, 2, − 8;	0, 4, − 8;	0, 6, − 8; 0, 8, − 8	
−1	20	Top		−1, − 3, 5;	−1, − 1, 5;	−1, 1, 5	−1, 3, 5;	−1, 5, 5;	−1, 7, 5	22
			−1, − 5, 3;	−1, − 3, 3;	−1, − 1, 3;	−1, 1, 3	−1, 3, 3;	−1, 5, 3;	−1, 7, 3	
			−1, − 5, 1;	−1, − 3, 1;	−1, − 1, 1;	−1, 1, 1	−1, 3, 1;	−1, 5, 1;	−1, 7, 1	
			−1, − 5, − 1;	−1, − 3, − 1;	−1, − 1, − 1;	−1, 1, − 1	−1, 3, − 1;	−1, 5, − 1;	−1, 7, − 1	
				−1, − 3, − 3;	−1, − 1, − 3;	−1, 1, − 3	−1, 3, − 3;	−1, 5, − 3;	−1, 7, − 3	
	21	Bottom			−1, − 1, − 5;	−1, 1, − 5	−1, 3, − 5;	−1, 5, − 5;	−1, 7, − 5	23
					−1, − 1, − 7;	−1, 1, − 7	−1, 3, − 7;	−1, 5, − 7;	−1, 7, − 7	
						−1, 1, − 9	−1, 3, − 9;	−1, 5, − 9;	−1, 7, − 9	
−2	24	Top			−2, − 2, 6;	−2, 0, 6	−2, 2, 6			26
				−2, − 4, 4;	−2, − 2, 4;	−2, 0, 4	−2, 2, 4;	−2, 4, 4;	−2, 6, 4	
			−2, − 6, 2;	−2, − 4, 2;	−2, − 2, 2;	−2, 0, 2	−2, 2, 2;	−2, 4, 2;	−2, 6, 2	
			−2, − 6, 0;	−2, − 4, 0;	−2, − 2, 0;	−2, 0, 0	−2, 2, 0;	−2, 4, 0;	−2, 6, 0	
				−2, − 4, − 2;	−2, − 2, − 2;	−2, 0, − 2	−2, 2, − 2;	−2, 4, − 2;	−2, 6, − 2	
	25	Bottom			−2, − 2, − 4;	−2, 0, − 4	−2, 2, − 4;	−2, 4, − 4;	−2, 6, − 4	27
					−2, − 2, − 6;	−2, 0, − 6	−2, 2, − 6;	−2, 4, − 6;	−2, 6, − 6	
						−2, 0, − 8	−2, 2, − 8;	−2, 4, − 8;	−2, 6, − 8	
						−2, 0, − 10	−2, 2, − 10;	−2, 4, − 10;	−2, 6, − 10	
−3	28	Top		−3, − 3, 5;	−3, − 1, 5;	−3, 1, 5	−3, 3, 5;	−3, 5, 5		30
			−3, − 5, 3;	−3, − 3, 3;	−3, − 1, 3;	−3, 1, 3	−3, 3, 3;	−3, 5, 3		
			−3, − 5, 1;	−3, − 3, 1;	−3, − 1, 1;	−3, 1, 1	−3, 3, 1;	−3, 5, 1		
			−3, − 5, − 1;	−3, − 3, − 1;	−3, − 1, − 1;	−3, 1, − 1	−3, 3, − 1;	−3, 5, − 1		
				−3, − 3, − 3;	−3, − 1, − 3;	−3, 1, − 3	−3, 3, − 3;	−3, 5, − 3		
	29	Bottom		−3, − 3, − 5;	−3, − 1, − 5;	−3, 1, − 5	−3, 3, − 5;	−3, 5, − 5		31
					−3, − 1, − 7;	−3, 1, − 7	−3, 3, − 7;	−3, 5, − 7		
						−3, 1, − 9	−3, 3, − 9			
−4	32	Top			−4, − 4, 4;	−4, − 2, 4	−4, 0, 4;	−4, 2, 4;	−4, 4, 4	33
					−4, − 4, 2;	−4, − 2, 2	−4, 0, 2;	−4, 2, 2;	−4, 4, 2	
					−4, − 4, 0;	−4, − 2, 0	−4, 0, 0;	−4, 2, 0;	−4, 4, 0	
					−4, − 4, − 2;	−4, − 2, − 2	−4, 0, − 2;	−4, 2, − 2;	−4, 4, − 2	
						−4, − 2, − 4	−4, 0, − 4;	−4, 2, − 4;	−4, 4, − 4	
		Bottom (single)					−4, 0, − 6;	−4, 2, − 6;	−4, 4, − 6	34

TABLE X2.1 *Continued*

Part A. Whole-step Samples										
L	Left Page No.	Position	*L, j, g* of Samples On							Right Page No.
			Left or Single Page				Right Page			
									−4, 2, − 8; −4, 4, − 8	
−5	35	Top	−5, − 5, 3; −5, − 5, 1; −5, − 5, − 1;	−5, − 3, 3; −5, − 3, 1; −5, − 3, − 1; −5, − 3, − 3;	−5, − 1, 3; −5, − 1, 1; −5, − 1, − 1; −5, − 1, − 3; −5, − 1, − 5;	−5, 1, 3 −5, 1, 1 −5, 1, − 1 −5, 1, − 3 −5, 1, − 5	−5, 3, 3 −5, 3, 1 −5, 3, − 1 −5, 3, − 3 −5, 3, − 5			37
	36	Bottom (single)				−5, 1, − 7	−5, 3, − 7			
−6	38	Single	−6, − 4, 2; −6, − 4, 0; −6, − 4, − 2;	−6, − 2, 2; −6, − 2, 0; −6, − 2, − 2; −6, − 2, − 4;	−6, 0, 2; −6, 0, 0; −6, 0, − 2; −6, 0, − 4; −6, 0, − 6;	−6, 2, 2 −6, 2, 0 −6, 2, − 2 −6, 2, − 4 −6, 2, − 6				
−7	39	Single	−7, − 3, 1; −7, − 3, − 1;	−7, − 1, 1; −7, − 1, − 1;	−7, 1, 1 −7, 1, − 1					
Part B. Half-step Samples										
1½	40	Single	1½, − 1½, 1½; 1½, − 1½, ½; 1½, − 1½, − ½; 1½, − 1½, − 1½;	1½, − ½, 1½; 1½, − ½, ½; 1½, − ½, − ½; 1½, − ½, − 1½;	1½, ½, 1½; 1½, ½, ½; 1½, ½, − ½; 1½, ½, − 1½;	1½, 1½, 1½ 1½, 1½, ½ 1½, 1½, − ½ 1½, 1½, − 1½				
1	41	Top		1, − 2, 1 1, − 2, 0; 1, − 2, − 1	1, − 1, 2; 1, − 1, 0; 1, − 1, − 2;	1, 0, 2 1, 0, 1 1, 0, 0 1, 0, − 1 1, 0, − 2	1, 1, 2 1, 1, 0; 1, 1, − 2	1, 2, 1 1, 2, 0 1, 2, − 1		42
½	43	Top	½, − 2½, ½; ½, − 2½, − ½;	½, − 1½, 1½; ½, − 1½, ½; ½, − 1½, − ½; ½, − 1½, − 1½;	½, − ½, 2½; ½, − ½, 1½; ½, − ½, ½; ½, − ½, − ½; ½, − ½, − 1½;	½, ½, 2½ ½, ½, 1½ ½, ½, ½ ½, ½, − ½ ½, ½, − 1½	½, 1½, 1½ ½, 1½, ½; ½, 1½, − ½; ½, 1½, − 1½	½, 2½, ½ ½, 2½, − ½		45
	44	Bottom			½, − ½, − 2½;	½, ½, − 2½				47
0	46	Top	0, − 3, 0	0, − 2, 1; 0, − 2, − 1;	0, − 1, 2 0, − 1, 1; 0, − 1, 0 0, − 1, − 1; 0, − 1, − 2	0, 0, 3 0, 0, 1 0, 0, − 1 0, 0, − 3	0, 1, 2 0, 1, 1; 0, 1, 0 0, 1, − 1; 0, 1, − 2	0, 2, 1 0, 2, − 1	0, 3, 0	
	40	Bottom (single)								
−½	49	Top	−½, − 2½, ½; −½, − 2½, − ½;	−½, − 1½, − ½; −½, − 1½, ½; −½, − 1½, − ½; −½, − 1½, − 1½;	−½, − ½, 2½; −½, − ½, 1½; −½, − ½, ½; −½, − ½, − ½; −½, − ½, − 1½;	−½, ½, 2½ −½, ½, 1½ −½, ½, ½ −½, ½, − ½ −½, ½, − 1½	−½, 1½, 1½ −½, 1½, ½; −½, 1½, − ½; −½, 1½, − 1½	−½, 2½, ½ −½, 2½, − ½		51
	50	Bottom			−½, − ½, − 2½;	−½, ½, − 2½				
−1	52	Top		−1, − 2, 1 −1, − 2, 0; −1, − 2, − 1	−1, − 1, 2; −1, − 1, 0; −1, − 1, − 2;	−1, 0, 2 −1, 0, 1 −1, 0, 0 −1, 0, − 1 −1, 0, − 2	−1, 1, 2 −1, 1, 0; −1, 1, − 2	−1, 2, 1 −1, 2, 0 −1, 2, − 1		53
−1½	54	Single	−1½, − 1½, 1½; −1½, − 1½, ½; −1½, − 1½, − ½; −1½, − 1½, − 1½;	−1½, − ½, 1½; −1½, − ½, ½; −1½, − ½, − ½; −1½, − ½, − 1½;	−1½, ½, 1½; −1½, ½, ½; −1½, ½, − ½; −1½, ½, − 1½;	−1½, 1½, 1½ −1½, 1½, ½ −1½, 1½, − ½ −1½, 1½, − 1½				

X2.6.2 Discard the vinyl sheets and the pages behind them containing the OSA-UCS notations in the original arrangement; retain the latter for possible future use should it be desired to restore the original arrangement of the samples.

X2.6.3 Prepare (following Table X2.1) or obtain new notation sheets corresponding to the new sample arrangement.

X2.6.4 Obtain archival-quality polyethylene or polypropylene sheets to hold the samples. Place the samples in the new sheets, following the order given on the new notation sheets.

Place the plastic and notation sheets alternately in the atlas, in numerical order.

X2.6.5 This arrangement requires more pages than the original, but presents the colors in orderly arrays based on lightness levels. The atlas can easily be indexed by lightness level.

X3. EXAMPLE OF ASSIGNING AN OSA-UCS NOTATION

X3.1 Object-color test specimen A is most nearly similar to, but slightly darker than, OSA-UCS atlas sample (−3,5,1).

X3.2 When placed between atlas samples (−3,5,1) and (−4,4,0), test specimen A appears closer in lightness to (−3,5,1) and is estimated to have $L = -3.3$.

X3.3 There is no atlas sample (−5,5,1) so (−1,5,1) was selected for use in determining chromaticness. When placed between atlas samples (−3,5,1) and (−1,5,1), test specimen A appears more yellow and less gray than the two atlas samples. Increasing the *j*, or yellowness, one 2-unit step gives the atlas sample (−1,7,1).

X3.4 When placed between atlas sample (−3,5,1) and (−1,7,1), test specimen A looks about half way between them in yellowness. Its notation is therefore estimated to be $j = 6$ and $g = 1$, giving it the notation of (−3.3,6,1). It is useful to remember that the larger are the values of *j* and *g* for a color, the higher is the chroma of the color. See Table 2.

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