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16. Abstract

This study was designed to provide photometric information about current U.S. low-beam headlamps. The sample included 35 low-beam headlamps manufactured for use on the 23 best-selling passenger cars, light trucks, and vans for model year 1997. These 23 vehicles represent 45% of all vehicles sold in the U.S. The lamps were purchased directly from vehicle dealerships, and photometered in 0.5° steps from 45° left to 45° right, and from 5° down to 7° up. The photometric information for each lamp was weighted by 1997 sales figures for the corresponding vehicle. The results are presented both in tabular form for the 25th-percentile, the median (50th-percentile), and the 75th-percentile luminous intensities, as well as in graphical form (for the median luminous intensities, and median illuminance values reaching the road surface). The information is presented in aggregate form, as well as broken down by vehicle type and light source.

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INTRODUCTION

The effectiveness of a variety of driver visual aids depends on the illumination from headlamps. For example, retroreflective traffic signs and lane markings are visible primarily because of the reflected headlamp illumination. Many factors affect the amount of illumination reaching targets of interest, including road geometry, headlamp aim, and dirt on the headlamps. However, the most important factor is the light output of the headlamps. As discussed by Sivak, Flannagan, and Sato (1994), the expected headlamp light output cannot be obtained by examining headlamp light-output regulations. There are at least two reasons why regulations do not yield such information. First, the light-output regulations (such as the U.S. Federal Motor Vehicle Safety Standard 108) specify a minimum and/or maximum light output at only a limited number of test points; they do not constrain the headlamp beam to a unique light pattern. Second, not all production lamps meet the relevant regulations (Sivak and Flannagan, 1993).

The only detailed data on actual headlamp intensities in the open literature based on a large number of headlamps was published by Sivak et al. (1994). That study provided summary information on 150 low-beam headlamps manufactured for use in the U.S., Europe, and Japan. However, (a) the sample in that study was not a systematic one, and (b) those lamps are now somewhat dated (they were manufactured from the early 1980s through the early 1990s).

The present study was designed to develop a market-weighted database of current U.S. low-beam headlamps. The main features of this study were as follows: First, the lamps to be photometered were directly purchased from vehicle dealerships, thus avoiding the potential problem of self-selection with donated lamps. Second, the selected lamps were designed for use on 45% of all cars, light trucks, and vans currently being sold in the U.S. Third, the obtained photometric information was weighted by the current sales figures for the respective vehicle models. Fourth, in addition to aggregate information for all vehicles, separate analyses were performed for cars versus light trucks and vans, and for the different light sources used in the lamps. Fifth, data were also collected on the differences among lamps built for the same side of a given vehicle model, and on the differences between lamps built for the two different sides of a given vehicle model. Sixth, information was obtained on the effect on luminous intensity of changing voltage from 12.8 V to either 12.0 V or 13.5 V.

METHOD

Approach

The approach consisted of the following steps:

(1) Obtain luminous-intensity matrix for lamps designed to be used on the best-selling cars, light trucks, and vans.

(2) Use the current sales data for the respective vehicles to derive a sales-weighted distribution of luminous intensities at each test point.

(3) For each test point, calculate selected percentiles—25th, 50th (median), and 75th—of the sales-weighted distribution of luminous intensities.

Photometry

We determined the luminous intensities at the 25th percentile, the median (50th percentile), and the 75th percentile for 4,525 test points. These test points were in a rectangular matrix defined by the following ranges of horizontal and vertical angles (in relation to the headlamps axes). In the horizontal direction, the angles ranged from 45° left (L) to 45° right (R) in steps of 0.5°. In the vertical direction, the angles ranged from 5° down (D) to 7° up (U) in steps of 0.5°.

The measurements were made in a photometry lab using a goniometer. Complete luminous-intensity matrices were obtained at 12.8 V. In addition, for one test point (H, V) luminous intensity was also measured at 12.0 V and 13.5 V.

Visual aiming was used to align the lamps prior to the photometry. For all lamps this was performed by the same person—a lighting engineer with nine years of headlighting experience.

Sample

A total of 35 lamps, manufactured for use on 1997 model vehicles, constituted the sample. The lamps were purchased in vehicle dealerships. These lamps were manufactured for use on 23 vehicles: the 15 best-selling cars, and the 8 best-selling light trucks and vans in the U.S. for the first 9 months of the 1997 model year (October 1996 through June 1997) (Ward's Automotive Reports, 1997). The 15 cars constituted 44.8% of all cars sold during that time period. For the 8 light trucks and vans the corresponding figure was 45.7%. Overall, the 23 vehicles constituted 45.2% of all vehicles sold (5,043,063 of 11,151,277 vehicles) (Ward's Automotive Reports, 1997). The sales figures for each vehicle for the first nine months of the 1997 model year were also obtained from Ward's Automotive Reports (1997).

Of the 35 lamps, 29 were left-side lamps (1 lamp each for 17 vehicles, and 2 lamps each for 6 vehicles), and 6 were right-side lamps (see Table 1). A breakdown of lamps by light source and type of vehicle for the 23 vehicle models surveyed is shown in Table 2. The primary analyses were made on the left-side lamps only.

Table 1
The number of left-side and right-side lamps in the sample by vehicle type and light source.

Criterion	Number of lamps	
	Left	Right
One left lamp for each of the 15 best-selling cars	15	0
One additional left lamp and one right lamp for the 3 best-selling cars using HB2, HB4, and HB5 lamps, respectively	3	3
One left lamp for each of the 8 best-selling light trucks and vans	8	0
One additional left lamp and one right lamp for the 3 best-selling light trucks or vans using HB1, HB4, and HB5 lamps, respectively	3	3
Total	29	6

Table 2
Breakdown of the light sources used in the lamps for the 15 best-selling cars and 8 best-selling light trucks and vans.

Light source	Cars	Light trucks and vans	All vehicles	Sales-weighted percentage of all vehicles
HB1 (9004)	0	2	2	9.3
HB2 (H4)	3	0	3	12.5
HB4 (9006)	6	2	8	34.3
HB5 (9007)	6	4	10	43.9
Total	15	8	23	100.0

RESULTS AND DISCUSSION

Light-output distributions for the overall sample and by vehicle type

Figure 1 presents isointensity diagrams corresponding to the median (50th percentile) luminous intensities for the sales-weighted sample representing the low-beam headlamps on current cars, light trucks, and vans. Figure 1 is based on all 29 left-side lamps (1 lamp each for 17 vehicles, and 2 lamps each for 6 vehicles). (For the 6 vehicles with 2 lamps each, the mean values for the 2 respective lamps were used.) Table 3 lists the 25th percentile, the median, and the 75th percentile luminous intensities. The horizontal steps in Table 3 are 0.5° between 0° and 5°, 1° between 5° and 10°, and 5° between 10° and 45° (all for left or right).

Figures 2 and 3 show isointensity diagrams for the median luminous intensities separately for a sales-weighted distribution of cars, and for a sales-weighted distribution of light trucks and vans. Tables 4 and 5 list the 25th percentile, the median, and the 75th percentile luminous intensities by vehicle type. The light distributions for the two vehicle types are similar overall, but there are some differences. One difference is that the high intensity zones tend to be more skewed to the right for light trucks and vans than for cars. This becomes apparent, for example, when examining the 3,000-cd lines in Figures 2 and 3. Another difference is that the peak intensity values are smaller for cars than for light trucks and vans: For example, the peak median value for cars is 22,721 cd at 1D, 2R (see Table 4), while the peak median value for light trucks and vans is 26,663 cd at 1.5D, 1.5R (see Table 5). One reason for these differences is the fact that one light source (HB2) was present in our sample of lamps for cars but not light trucks and vans, and the converse was the case for another light source (HB1) (see the discussion and figures below).

The calculated isoilluminance curves at the road surface (in vertical lux) for a pair of lamps having the median light output for cars are shown in Figure 4. The illuminance levels represented in the diagram are based on the combined effects of two headlamps mounted in the normal left and right positions on a vehicle. However, we used the intensity values from our sample of left lamps twice, for both the left and right positions. There are two reasons for this. First, our analysis, which is presented below, showed that left-side lamps are similar to right-side lamps. Second, we have a better estimate of the light output of the left-side lamps because of a larger sample of left-side lamps. Analogous isoilluminance curves for light trucks and vans are shown in Figure 5. The lamp mounting heights and the lamp separations that were used in these calculations were those from a recent survey of the locations of headlamps in vehicles sold in the U.S. (Sivak, Flannagan, Budnik, Flannagan, and Kojima, 1997). The values used for the lamp mounting height (center to ground) and the lamp separation (center to center) were 0.62 m and 1.12 m for cars, and 0.83 m and 1.30 m for light trucks and vans.

Figures 4 and 5 reveal that the highest illuminance curve (the 50-lux curve) extends somewhat further from light trucks and vans than from cars. This is a consequence of the above-

mentioned higher peak intensity and greater mounting height of the lamps on light trucks and vans. On the other hand, the lower illuminance curves extend further from cars than light trucks and vans. (See for example, the 2-lux curves.) This effect is a consequence of the fact that the car lamps have higher intensity just below the horizontal (i.e., between the horizontal and 0.5° down) and near the vertical (see Tables 4 and 5). (The influence of the intensity differences just below the horizontal is partially offset by the greater mounting height of the lamps on light trucks and vans.)

Light-output distributions by light source

Figures 6 through 9 present isointensity diagrams by light source for the median luminous intensities (again sales-weighted). Tables 6 through 9 list the actual median luminous intensities. There are two apparent differences among the light sources. First, while the HB4 and HB5 lamps have relatively symmetrical light distributions, the HB1 and HB2 lamps have relatively asymmetrical light distributions—skewed to the right for the HB1 lamps, and to the left (typical of the European beam pattern) for the HB2 lamps (see Figures 6 through 9, especially the 3,000-cd lines). (Whether the distributions are skewed or not, they are all displaced to the right and down.) Second, the peak intensity of the HB2 lamps is substantially below that of the other three types of lamps. The respective peak median values are 17,932 cd for the HB2 lamps, compared with 25,960, 25,198, and 27,021 cd for the HB1, HB4, and HB5 lamps, respectively (see Tables 6 through 9). As indicated above, these light-source differences contribute to the differences between the vehicle types because HB1 light sources were not present in our sample of cars, and HB2 light sources were not present on our sample of light trucks and vans.

Consistency of lamps built for one side, and for the two different sides, of a vehicle

For each of six vehicles (three in each vehicle category) we measured two left lamps and one right lamp. This allowed us to compare the consistency of light-output distributions for lamps built for the same side of a vehicle and lamps built for the two different sides of a vehicle. Consistency was measured by computing a correlation coefficient for each pair of luminous-intensity matrices of interest (i.e., the first left lamp versus the second left lamp, the first left lamp versus the right lamp, and the second left lamp versus the right lamp). For each pair of lamps, the calculations were performed for the lamps as aimed visually, as well as for 8 conditions in which the lamps were misaimed in relation to each other by 0.5° in all 4 cardinal directions (i.e., left, right, down, and up), and their 4 combinations (i.e., left and down, left and up, right and down, and right and up). (This was done to compensate for possible variations in the way the lamps were visually aimed.) This process yielded 9 correlation coefficients for each pair of left lamps and 9 coefficients for each of the two pairings of each right lamp with the two corresponding left lamps

(for a total of 27 correlation coefficients for each vehicle). We selected the maximum from among the 9 correlation coefficients for each pairing of lamps.

The results showed a high level of consistency for both left-versus-left and left-versus-right comparisons, with the maximum correlation for each pair of lamps being 0.936 or greater. However, the maximum coefficients for the left-versus-right comparisons (the range over the six vehicles being 0.936 through 0.988) were consistently lower than those for the left-versus-left comparisons (the range over the six vehicles being 0.990 through 0.997). These results suggest that, as expected, it is easier to produce similar lamps of the same design (for a given side of a vehicle) than it is to produce similar lamps with the different designs required by the constraints of the available space on the different sides of a vehicle.

Light output by voltage

For each lamp, the light output at one test point (H, V) was measured at three different voltages: 12.0, 12.8, and 13.5 V. The mean light outputs (normalized for output at 12.8 V) were 0.81 at 12.0 V, 1.00 at 12.8 V, and 1.19 at 13.5 V. These values are in good agreement with the values derived from the standard formula $(V_1/V_2)^{3.4}$ (IES, 1984): 0.80 at 12.0 V, 1.00 at 12.8 V, and 1.20 at 13.5 V.

Uses and limitations of the present data

The present analyses are not based on a complete census of current low-beam headlamps in the U.S., but on a sample constituting 45% of all lamps. However, we do not have reasons to believe that there are any systematic differences between the lamps that were sampled and those that were not. Consequently, we believe that the data presented in this report provide valid estimates of the luminous intensities that can be expected at various angles with respect to the headlamp axes of low-beam headlamps currently sold in the U.S. Thus, the data could be used to calculate the expected illuminance reaching targets with known geometric relationships to the headlamps, such as traffic signs, road delineation, the eyes of an oncoming driver, or rearview mirrors on a preceding vehicle. For example, Figures 4 and 5 provide calculated illuminance values at the road surface in front of a vehicle.

The present data should not be used to calculate gradients of luminous intensities for adjacent points in space (e.g., for estimating the sharpness of the cutoff that is important for visual aiming of the beam pattern). This is because the transitions from the more intense to the less intense parts of the beam pattern are not precisely in the same locations for all lamps. Consequently, although the present analysis provides valid estimates of luminous intensities for individual points, a computation of gradients between points based on the present analysis would underestimate the actual gradients. This caveat applies not only to the present data, but also to any aggregate data that are not adjusted for the location of the cutoff.

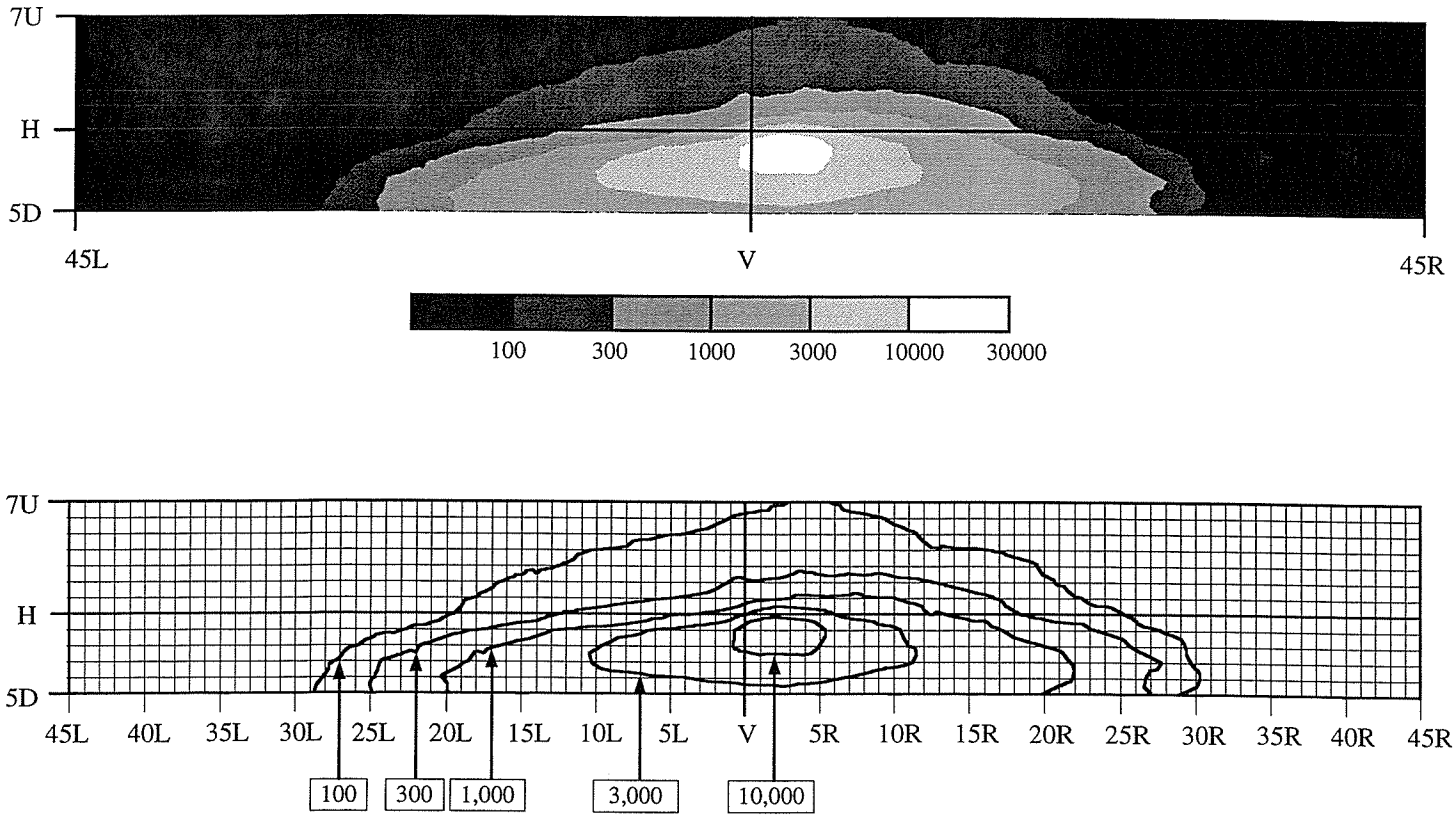

Figure 2. Isocandela diagrams of the median (50th percentile) luminous intensities for the sales-weighted sample representing the low-beam headlamps on current cars in the U.S. The two panels represent the same information in different formats. (Test voltage 12.8 V.)

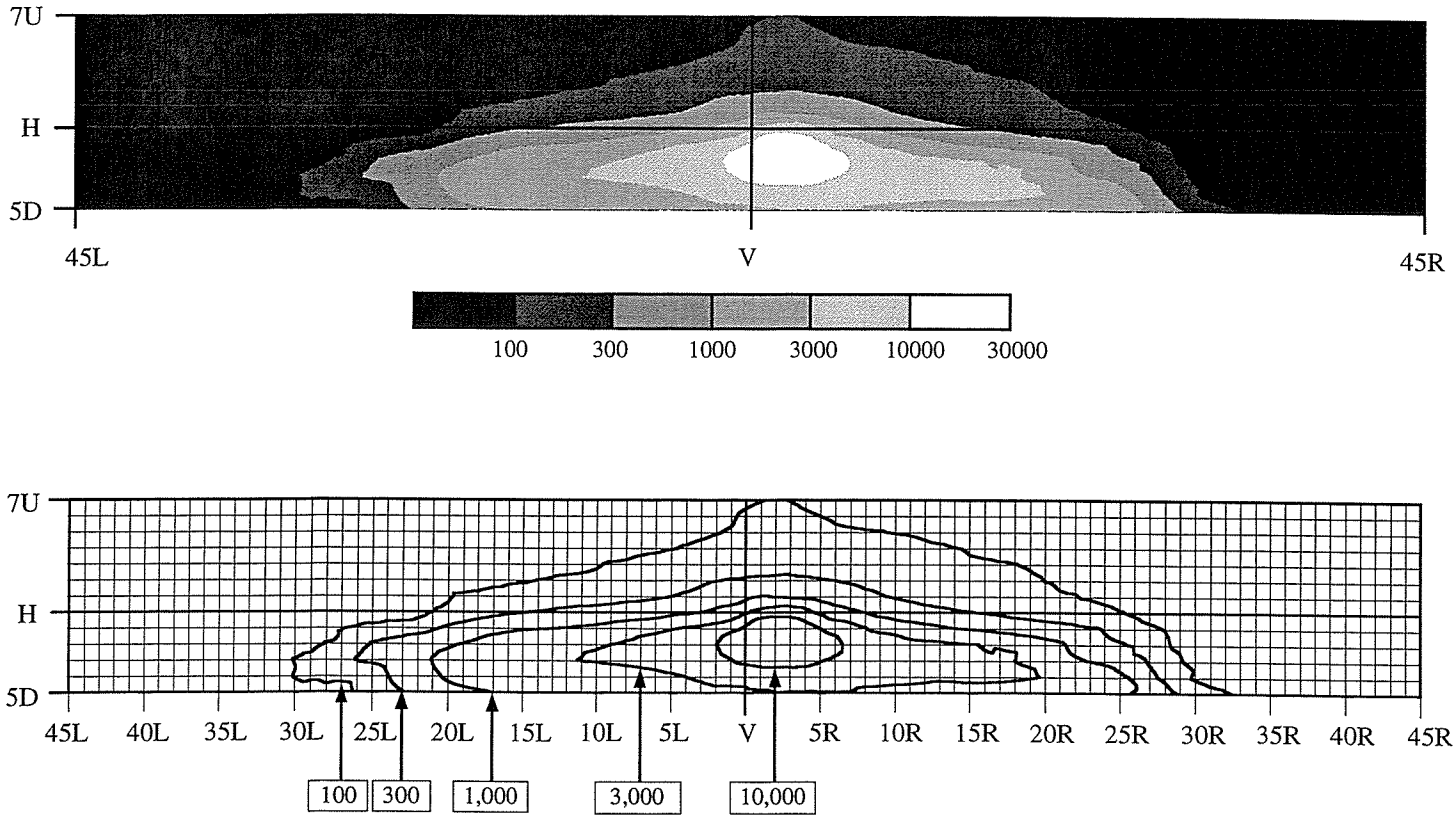

Figure 3. Isocandela diagrams of the median (50th percentile) luminous intensities for the sales-weighted sample representing the low-beam headlamps on current light trucks and vans in the U.S. The two panels represent the same information in different formats. (Test voltage 12.8 V.)

	0.5R	1R	1.5R	2R	2.5R	3R	3.5R	4R	4.5R	5R	6R	7R	8R	9R	10R	15R	20R	25R	30R	35R	40R	45R
	69	70	71	72	72	71	70	68	66	65	61	57	56	53	52	42	34	19	12	9	4	3
7U	93	97	100	102	104	106	106	94	85	81	77	72	68	65	65	53	45	31	18	14	12	11
	128	129	129	131	132	134	127	124	120	118	114	110	104	97	93	76	56	37	23	18	17	16
	76	78	79	79	79	78	76	72	71	69	66	61	60	57	55	45	37	21	12	9	5	3
6.5U	105	108	111	117	118	118	115	115	96	90	86	82	77	75	73	54	47	31	18	15	13	11
	138	141	143	144	144	144	141	136	134	132	126	119	112	111	100	83	59	39	23	19	18	16
	84	86	86	86	86	85	84	81	79	76	70	67	64	62	58	49	39	21	13	11	5	3
6U	115	121	124	127	129	128	127	128	116	109	103	99	94	91	81	59	49	31	19	16	13	11
	156	157	159	159	158	162	160	152	149	145	136	128	121	117	114	88	61	40	23	18	17	16
	96	98	98	98	98	95	93	89	86	84	78	75	70	67	63	54	43	22	15	10	5	3
5.5U	133	140	146	146	143	140	141	140	142	134	122	117	110	105	92	62	50	33	20	17	13	11
	171	179	181	180	179	178	181	172	169	166	156	145	142	137	130	99	69	43	24	22	18	16
	105	106	107	108	109	109	108	104	99	95	87	84	79	75	70	56	45	25	15	9	5	3
5U	145	155	165	168	166	163	159	154	154	151	141	136	128	123	115	68	53	33	22	17	13	11
	191	200	206	206	204	203	206	200	191	187	175	168	166	156	145	108	76	45	25	19	20	16
	121	123	123	124	125	124	122	116	112	108	98	92	90	83	78	61	49	28	14	10	6	4
4.5U	168	181	185	188	187	187	187	182	194	190	168	158	145	137	126	74	58	36	24	17	12	11
	206	216	240	240	240	244	240	233	228	222	212	210	189	172	157	124	88	50	26	20	19	16
	133	138	140	140	141	141	139	134	126	120	111	103	100	96	89	64	51	28	14	9	6	4
4U	183	204	211	213	214	218	228	221	221	209	189	177	164	154	141	110	74	37	25	18	12	11
	243	246	248	268	281	280	277	274	265	261	251	234	222	192	172	138	94	54	28	21	19	16
	160	162	164	164	164	163	159	154	151	145	135	124	114	108	108	70	51	30	15	11	6	5
3.5U	193	214	245	249	247	248	255	268	259	246	221	213	189	178	154	130	87	40	25	19	13	11
	291	294	298	320	327	335	325	323	317	309	298	272	248	223	202	164	109	60	35	25	24	16
	187	189	189	192	193	189	183	178	174	167	155	142	134	122	122	77	54	31	16	14	8	4
3U	212	224	239	255	260	286	284	279	273	269	251	228	207	195	188	136	87	41	27	19	13	11
	355	358	356	389	407	406	393	396	392	377	351	313	273	256	223	198	114	67	38	28	27	17
	209	224	236	233	234	227	223	221	220	208	185	164	156	140	136	91	59	33	16	14	7	4
2.5U	258	263	264	276	282	286	288	288	286	284	272	260	237	228	212	143	94	44	27	18	13	11
	433	469	472	510	512	516	510	507	487	446	405	359	338	323	304	223	128	76	41	30	27	20
	248	258	258	270	284	275	282	287	288	272	238	202	175	165	154	111	69	36	19	14	7	4
2U	354	366	368	365	356	358	359	354	354	357	320	297	284	264	254	184	103	47	26	19	12	10
	555	590	631	645	672	666	717	710	645	662	554	501	489	423	395	275	141	83	42	31	26	18
	303	323	332	336	338	344	351	343	316	333	313	282	233	223	197	130	80	41	21	13	8	3
1.5U	508	526	540	553	554	555	549	534	518	522	463	408	388	344	309	218	114	53	29	19	12	10
	766	840	882	919	974	1003	1011	986	923	820	1000	907	765	676	642	381	191	92	45	29	23	17
	416	426	483	542	598	658	685	681	607	535	475	403	309	260	226	151	92	50	23	14	7	4
1U	1021	1001	1023	938	937	856	894	833	761	760	743	614	536	461	403	250	135	75	31	19	13	10
	1207	1450	1574	1700	1688	1554	1463	1782	1972	1960	1892	1501	1376	1146	1040	511	238	104	52	31	22	20
	896	1176	1318	1536	1627	1523	1551	1551	1308	1010	727	592	475	409	351	189	108	63	25	13	7	6
0.5U	1578	1909	2080	2564	2606	2487	2142	2058	1864	1599	1106	910	735	629	525	336	184	89	32	19	12	10
	3016	3166	3103	3065	3621	3836	4037	4213	4314	4049	3254	2217	2254	1926	1591	835	384	142	60	31	21	20
	2924	3901	4524	5040	5450	5720	5557	4211	3084	2327	1486	1008	729	554	463	284	152	57	23	10	8	7
0	4015	5414	6372	6838	6807	6292	5828	5445	4695	3918	2513	1642	1248	1037	822	453	205	106	31	14	10	10
	6577	7405	8034	8176	8342	8386	8277	7548	7229	6164	5466	4034	3352	3194	2408	1153	582	162	60	30	12	13
	8467	11081	13284	14066	13065	11629	9593	7707	5887	4569	2838	1946	1335	974	750	389	190	66	20	10	7	10
0.5D	11663	14396	15023	15467	15303	14658	13416	12300	10662	8737	4895	2880	2133	1809	1513	643	337	143	30	10	10	10
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1D	17224	19639	21560	22420	21901	19936	19582	17068	13658	12059	7221	4633	3333	2702	2169	1170	589	223	44	11	10	10
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1.5D	19244	21319	23256	24638	25320	24138	22083	19424	15810	13227	9813	7675	4945	3944	3360	1812	873	301	53	11	10	10
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2D	16691	18602	20784	21949	21607	21011	18961	17824	16529	15410	11072	7612	5959	4701	4006	2024	1069	392	63	14	10	10
	22487	24068	24460	25085	25168	24363	23395	22461	20689	18046	13792	9839	6771	5271	4822	3359	1892	570	161	38	20	18
	8646	9068	9356	9476	9657	9788	10124	9947	9350	8447	6511	5042	3845	3388	3080	1766	907	256	50	10	10	10
2.5D	12825	13827	14434	14643	14613	14765	14737	13850	12109	10899	9043	6465	5930	5201	4227	2736	1203	460	72	16	10	10
	17578	18931	19724	18937	18732	18889	18151	18043	17563	14525	10900	9568	7283	5901	5158	4067	2145	743	219	44	27	17
	6866	7099	7106	6946	6663	6508	6663	6748	6374	5823	5176	4319	3755	3400	3149	1835	1015	297	60	11	9	8
3D	9346	9236	9375	9399	9469	9313	9194	8834	8254	7394	7173	5721	4854	4289	3883	2727	1595	609	83	20	10	10
	11886	12463	13752	14194	14675	15081	14326	14430	13010	11393	9000	7657	6594	5809	5414	4494	1916	818	239	57	38	19
	4845	4952	5163	5065	4912	4816	4755	4690	4637	4383	3888	3518	3101	2838	2564	1797	1264	287	55	14	7	5
3.5D	5921	6019	5946	5964	6015	5861	5793	5748	5672	5327	4891	4627	4194	3847	3573	3092	1522	726	116	20	10	10
	8843	9082	9252	9407	9494	9616	9755	9788	9505	9204	7290	5927	5401	4907	4680	4337	2729	949	236	71	39	17
	3169	3139	3175	3184	3273	3327	3188	3080	3007	2835	2532	2393	2226	2106	2075	1511	959	280	52	15	8	5
4D	4553	4461	4211	4180	4212	4157	4054	4043	3879	3794	3745	3702	3597	3506	3103	2422	1652	666	131	32	13	10
	6113	6203	6291	6353	6363	6357	6345	6466	6754	6636	5944	4888	4212	3999	3930	3506	2979	1301	326	77	47	18
	2456	2438	2459	2412	2213	2302	2254	2267	2228	2211	2019	1824	1691	1649	1584	1211	843	269	49	14	8	5
4.5D	2986	3054	3084	3089	3063	3023	2945	2866	2855	2850	2793	2817	2660	2581	2441	2158	1529	598	103	34	16	10
	4405	4514	4573	4651	4721	4716	4693	4635	4461	4553	4440	4105	3410	3145	3111	2982	2699	1347	420	72	47	19
	1614	1610	1616	1648	1637	1626	1635	1669	1695	1679	1672	1561	1391	1320	1225	1027	662	223	51	14	10	5
5D	2275	2286	2303	2253	2219	2236	2252	2242	2220	2142	2087	2104	2076	1991	2004	1825	1321	620	94	37	18	10
	3102	3105	3211	3170	3124	3064	3134	3205	3286	3331	3416	3087	2645	2582	2476	2542	2473	1273	559	100	46	27

Table 4

Luminous intensities (cd) for the sales-weighted sample representing the low-beam headlamps on current cars in the U.S. The entries in each cell are (from top to bottom) the 25th percentile, the median (50th percentile), and the 75th percentile. (Test voltage 12.8 V.)

	45L	40L	35L	30L	25L	20L	15L	10L	9L	8L	7L	6L	5L	4.5L	4L	3.5L	3L	2.5L	2L	1.5L	1L	0.5L	0
	6	6	10	17	22	26	32	45	46	46	47	48	51	52	53	55	56	58	61	64	66	67	69
7U	16	16	21	24	30	30	38	48	50	53	57	60	62	64	67	69	70	72	73	77	79	84	80
	27	30	33	35	39	44	53	59	62	66	73	73	76	78	84	88	91	95	98	102	104	105	109
	6	6	9	17	21	27	35	49	51	51	50	53	56	57	58	60	60	62	65	69	72	73	75
6.5U	16	16	21	26	29	32	42	53	55	58	61	63	66	69	71	74	77	78	85	85	89	92	93
	27	29	32	35	39	47	55	63	69	71	74	77	84	91	93	95	98	101	101	105	114	115	117
	6	6	9	18	21	28	37	54	54	55	56	58	61	62	63	66	67	70	73	76	78	79	82
6U	16	17	21	26	32	36	45	58	61	62	64	66	72	75	78	82	83	88	94	96	101	106	109
	27	30	33	35	41	52	58	70	71	73	78	84	95	99	102	104	106	107	109	114	124	126	130
	6	6	9	16	21	29	38	58	60	62	66	69	73	75	75	77	79	80	82	87	90	92	95
5.5U	17	17	18	26	29	40	51	64	64	70	70	72	78	84	87	92	94	96	102	105	110	115	124
	26	30	31	39	46	55	60	88	81	81	86	98	104	105	108	108	110	108	116	124	136	139	142
	6	6	9	15	22	30	43	66	67	71	72	77	80	83	85	88	92	97	102	109	110	111	108
5U	18	17	16	28	31	41	54	70	75	80	89	93	98	98	101	103	107	108	112	115	122	126	132
	25	31	33	39	43	54	63	97	97	90	96	107	112	113	114	117	117	118	127	138	152	155	159
	6	6	10	14	22	33	47	70	76	79	80	85	92	98	101	106	112	113	117	124	128	131	128
4.5U	18	18	15	29	30	42	60	88	88	92	103	107	113	119	123	121	122	131	133	142	148	142	152
	26	32	34	42	46	59	69	107	111	112	116	123	126	126	127	129	131	133	140	151	161	165	171
	6	6	10	14	24	36	52	78	82	94	94	98	105	107	111	118	124	121	125	127	132	142	151
4U	19	18	16	28	33	44	70	99	101	105	113	121	126	129	130	132	137	145	150	156	163	174	175
	26	31	34	41	49	65	84	124	128	134	133	136	140	141	142	145	148	151	160	171	196	198	191
	6	6	10	15	25	40	58	88	99	112	111	115	121	126	132	135	130	131	135	140	142	147	161
3.5U	18	20	18	28	32	48	77	118	116	119	131	136	145	146	142	151	163	164	176	182	188	196	203
	28	32	35	41	45	68	103	149	151	157	158	161	157	158	160	161	164	174	187	225	270	245	227
	6	7	11	17	30	46	68	97	115	129	133	135	137	143	148	145	147	150	155	160	166	170	175
3U	19	21	18	26	35	54	90	129	130	133	143	146	154	161	165	172	176	178	192	215	225	240	261
	26	32	36	39	50	69	117	159	163	163	166	168	176	180	177	178	191	202	215	256	320	314	283
	6	7	11	19	26	48	77	118	136	142	146	151	155	164	160	163	167	172	177	184	188	200	201
2.5U	19	21	20	25	36	58	97	139	150	162	169	174	185	189	193	195	196	206	234	245	266	290	269
	24	34	33	38	49	73	155	176	175	182	186	189	194	200	212	222	237	255	274	305	340	344	367
	5	7	11	19	27	52	84	133	147	150	162	173	173	181	187	193	198	205	214	219	221	221	230
2U	18	22	21	26	44	64	109	153	165	175	176	192	206	208	213	216	221	229	252	282	307	317	318
	23	35	33	38	51	79	176	202	206	215	216	218	229	244	255	269	286	319	340	364	412	458	504
	5	7	11	19	27	52	88	146	159	173	186	197	210	219	225	229	235	241	248	260	265	274	288
1.5U	18	22	23	26	45	69	116	183	193	202	202	220	233	238	247	253	260	274	304	334	360	375	395
	22	36	33	43	57	92	196	229	235	248	252	261	281	298	322	345	368	397	436	480	572	648	768
	5	7	13	22	29	53	104	163	183	200	228	234	256	280	286	297	311	323	350	356	373	383	402
1U	16	21	22	27	50	78	134	213	230	246	258	280	296	305	317	329	348	362	385	416	459	503	593
	23	35	34	45	64	106	215	287	303	333	354	368	383	421	457	489	531	580	663	783	864	989	1163
	4	7	13	23	34	56	116	191	219	240	290	301	329	361	396	425	449	470	510	575	614	658	721
0.5U	16	19	20	28	55	88	168	276	298	326	346	391	465	500	527	529	542	568	609	669	787	920	1229
	23	34	29	42	72	130	252	367	394	450	482	531	592	667	738	762	789	856	991	1117	1312	1679	2040
	9	9	10	10	31	58	136	242	295	339	386	441	455	497	540	584	663	763	864	959	1159	1553	2140
0	10	10	13	28	54	93	197	371	430	491	571	645	918	963	905	990	1057	1145	1258	1412	1756	2235	2672
	13	20	24	38	87	156	308	608	675	754	829	898	1008	1154	1374	1464	1516	1574	1659	1876	2398	3257	4591
	10	10	10	10	33	90	164	356	441	598	650	787	902	1004	1133	1277	1451	1761	2116	2561	3194	4420	6683
0.5D	10	10	10	14	59	110	264	563	602	753	983	1293	1470	1541	1937	2243	2313	2444	2671	2949	3629	5424	8463
	10	18	19	30	92	262	585	1225	1357	1480	1627	1814	2010	2099	2308	2734	3028	3422	3884	4508	6265	8093	10667
	10	10	10	10	43	120	317	787	980	1271	1563	1861	2099	2264	2484	2944	3573	3930	4181	4569	6082	8856	12477
1D	10	10	10	21	71	163	540	1378	1530	1980	2422	3072	3368	3499	3737	3950	4505	4822	5618	7010	8946	10714	13954
	10	20	30	39	127	493	1066	1972	2295	2567	2857	3468	3866	4252	4482	5093	5832	7026	8613	9879	11849	14220	16972
	10	10	10	10	52	151	632	1647	1778	2015	2381	2945	3541	4214	4509	4807	5073	5381	5788	6314	7398	9313	11348
1.5D	10	10	10	22	91	299	847	2261	2665	3171	3627	4127	4648	4971	5311	5757	6336	7531	7867	8122	8789	10966	13677
	12	20	30	47	200	562	1310	2775	3028	3526	4279	4636	5347	6332	7296	7643	7899	8282	9476	11540	13740	15831	17971
	10	10	10	10	56	272	827	2096	2414	2873	3439	3981	4358	4451	4582	4825	5250	5710	5858	6249	7523	8160	9122
2D	10	10	10	30	138	462	1299	2887	3290	3642	3895	4481	5219	5395	5813	5867	5971	6552	6907	7885	9362	11036	12820
	14	20	31	75	278	616	1969	3247	3559	4159	4656	5326	5649	5995	6217	6585	7193	8100	9816	11494	12829	14082	15512
	10	10	10	11	80	329	1200	2569	2691	2965	3331	4077	4014	4094	4385	4626	4664	5071	5362	5694	6157	6964	7208
2.5D	10	10	10	37	205	566	1594	3099	3442	4017	4240	4494	4876	5148	5465	5573	5784	6156	7165	7687	8573	8885	8820
	22	29	33	80	291	879	2240	3815	4008	4327	4666	5082	5849	6147	6313	6583	6914	7447	8218	8995	10012	11486	12071
	10	10	10	11	115	519	1429	2233	2489	2849	3235	3602	3923	3993	4016	4055	4443	4657	4833	5019	5165	5331	6017
3D	10	14	13	48	245	800	1663	3094	3435	3557	3850	4039	4176	4449	4776	5137	5466	5926	6641	6645	6980	7147	7310
	23	28	46	111	367	1074	2292	3852	4037	4498	4398	4824	5473	5634	5851	6188	6563	6847	7041	7969	8653	9184	9571
	6	8	10	25	141	703	1309	2068	2207	2443	3202	3047	3281	3264	3365	3453	3684	3835	3897	3973	4052	4150	4528
3.5D	10	19	18	52	270	912	1901	2908	3113	3171	3271	3528	3880	4085	4198	4134	4225	4597	4680	4755	5280	5397	5399
	27	30	43	116	356	1200	2148	3638	3779	4102	3804	3825	4459	4514	4677	4969	5185	5471	6031	6416	6671	6635	6613
	6	8	11	28	198	853	1204	1726	1840	2012	2378	2467	2655	2688	2643	2633	2727	2790	2841	2899	2935	2986	3069
4D	14	21	24	67	279	1067	1835	2482	2574	2649	2695	2859	2883	2918	2957	3078	3256	3411	3528	3587	3674	3712	3805
	29	39	44	125	395	1155	2097	3357	3366	3303	3378	3367	3526	3671	3828	3960	4144	4313	4422	4616	4786	4752	4902
	7	9	11	28	211	823	1147	1476	1584	1876	1840	1845	1825	1948	2054	2114	2189	2265	2309	2309	2337	2344	2416
4.5D	16	21	24	71	304	975	1588	2049	2130	2194	2224	2307	2348	2371	2393	2481	2484	2520	2550	2594	2649	2712	2842
	30	39	43	133	414	1222	1926	2683	2700	2622	2547	2614	2750	2829	2905	2971	3307	3407	3580	3535	3529	3399	3494
	7	10	14	26	232	774	1170	1277	1395	1416	1336	1325	1424	1467	1447	1526	1569	1624	1638	1656	1678	1723	1769
5D	20	20	25	61	285	985	1388	1619	1673	1686	1800	1880	1921	1926	1929	1971	1986	2015	2035	2052	2090	2130	2204
	29	35	42	123	405	1090	1777	1918	1998	2075	2047	2049	2095	2124	2158	2228	2358	2406	2412	2451	2437	2450	2518

	0.5R	1R	1.5R	2R	2.5R	3R	3.5R	4R	4.5R	5R	6R	7R	8R	9R	10R	15R	20R	25R	30R	35R	40R	45R
	69	70	71	72	71	70	69	67	66	64	61	57	54	51	49	39	33	18	10	6	3	1
7U	82	85	86	88	90	106	106	105	104	104	94	87	78	76	75	53	44	24	15	12	7	4
	113	115	122	124	128	129	128	124	117	117	115	111	105	98	94	75	48	32	18	13	10	11
	76	78	79	79	79	77	75	72	70	69	65	61	58	54	52	44	35	18	10	5	3	1
6.5U	94	98	99	117	118	118	115	115	115	116	116	96	90	85	84	54	43	25	16	12	7	4
	121	127	133	137	140	141	138	135	134	133	130	120	114	113	103	82	51	32	19	14	10	11
	83	85	85	86	86	85	83	80	78	76	70	65	62	60	56	44	35	20	10	5	3	1
6U	115	121	124	127	129	128	127	128	128	128	128	119	112	103	93	59	49	25	16	13	8	4
	134	139	144	149	152	154	154	152	151	147	137	128	123	124	115	88	53	34	21	14	10	11
	96	97	97	98	98	95	93	89	86	84	78	74	70	66	62	44	38	21	10	5	3	1
5.5U	127	131	139	140	141	140	141	140	142	141	141	134	129	120	102	62	50	25	17	13	8	5
	148	155	161	165	170	172	175	174	170	163	156	146	142	143	133	99	57	37	22	15	11	11
	107	108	109	110	110	109	108	104	99	95	87	83	79	74	69	45	42	22	11	6	3	1
5U	143	148	154	155	155	154	154	154	154	154	152	148	144	138	115	65	52	25	17	13	9	5
	169	177	186	184	190	194	197	193	188	182	181	183	180	180	159	105	68	39	23	16	10	11
	123	122	123	124	124	124	122	116	111	107	98	91	89	83	76	47	42	22	11	6	3	1
4.5U	163	168	170	171	176	183	184	182	194	190	174	166	154	154	126	69	58	31	17	14	9	5
	183	200	212	219	223	228	228	223	218	211	219	220	210	194	163	123	80	40	24	16	10	11
	147	139	140	140	141	140	138	133	126	120	111	103	99	95	88	51	45	24	12	6	3	1
4U	179	183	184	185	191	208	228	216	221	209	189	187	171	171	141	110	74	32	17	14	9	5
	209	228	240	253	251	258	266	259	251	251	250	241	234	197	186	138	89	42	26	18	11	11
	166	163	165	166	165	163	159	153	150	143	132	122	113	107	115	62	44	25	12	6	5	1
3.5U	192	199	200	202	224	245	254	268	259	246	221	213	193	178	160	130	87	31	19	15	9	6
	247	274	293	308	314	336	329	317	306	294	284	270	262	232	205	187	101	50	28	23	13	11
	182	187	189	193	195	191	185	178	173	165	153	141	133	121	135	73	45	27	13	6	3	1
3U	226	222	231	229	238	268	284	287	280	283	251	228	207	197	200	148	84	35	19	15	9	7
	302	327	355	381	399	412	402	382	368	349	335	328	303	262	245	207	114	64	31	21	16	11
	206	209	211	221	224	220	214	206	199	192	179	166	157	145	149	88	48	27	14	7	4	1
2.5U	252	255	261	263	271	294	309	303	304	294	277	304	279	314	267	175	96	36	20	16	9	7
	402	433	464	505	527	537	535	530	557	480	435	399	357	369	359	273	132	76	34	20	15	11
	248	257	251	251	251	259	254	243	226	217	206	194	204	178	168	108	54	28	14	7	4	1
2U	310	315	330	340	350	362	369	375	387	401	407	403	470	419	380	220	118	40	22	16	9	8
	560	593	631	672	694	750	797	791	778	694	604	547	545	573	513	337	167	86	35	22	15	11
	303	322	331	331	313	310	314	299	285	270	272	258	269	241	242	129	58	30	15	6	4	1
1.5U	400	441	477	508	535	564	575	588	604	642	599	685	685	638	609	292	136	47	22	15	9	8
	875	918	989	1064	1057	1081	1146	1154	1049	996	1094	973	957	870	796	453	233	87	36	29	15	11
	415	421	427	467	522	496	592	590	504	427	374	345	339	321	298	149	68	31	18	6	4	1
1U	668	711	786	820	889	976	1338	1313	1222	1181	1228	1288	1129	1036	1010	355	157	62	27	15	10	9
	1384	1615	1765	1806	1899	1837	1789	1899	2222	2284	2085	1670	1478	1345	1102	719	308	102	49	22	16	11
	769	1020	1083	1257	1294	1375	1484	1428	1251	956	641	555	525	481	438	192	93	34	21	7	4	1
0.5U	1641	2003	2204	2726	2845	2652	2499	2274	2032	2011	2047	1901	1475	1367	1355	486	185	87	28	14	9	8
	2363	2794	3105	3083	3686	3881	4063	4227	4316	4175	3970	3461	2657	2238	1738	976	482	154	56	20	17	11
	2920	3919	4529	5154	5573	5697	5510	4731	3948	3390	1993	1412	1082	869	734	302	133	39	10	8	4	2
0	3907	5099	6571	6810	6501	5976	5903	5865	5423	4364	2972	2297	2002	1790	1592	859	245	105	27	13	10	9
	6009	7330	8068	8278	8635	8890	8293	8049	7726	6981	6536	5834	4350	3470	2900	1260	603	184	54	19	10	10
	9715	12402	13987	14798	14101	13347	11268	9812	7892	5613	3771	2176	1852	1382	1163	600	190	29	10	8	4	2
0.5D	11895	14497	15786	16434	16111	14820	13404	12215	10576	8715	5002	3748	3373	2736	2059	1057	337	144	29	10	10	10
	13147	15675	17223	18220	17766	16672	15916	14650	13110	11472	9775	7836	6002	4573	3618	1775	840	289	65	18	10	10
	15701	18209	18912	16707	14320	12400	10544	8993	7553	6204	4304	3281	2379	1979	1721	880	248	45	10	8	4	2
1D	17098	19206	21611	22721	22457	19734	17029	15218	13293	11900	7150	4763	4090	3820	3768	1324	527	194	43	10	10	10
	18316	20512	22482	24341	25242	24038	23819	22740	20433	17783	13407	10266	7692	5925	4383	2114	988	431	69	13	10	10
	13784	14620	14157	13298	12263	11853	11335	10795	10153	8086	5497	3454	2589	2238	2027	1084	287	65	10	8	4	2
1.5D	15835	18245	19811	21061	21349	20744	18773	16452	13889	10993	8175	6671	5324	4145	3900	1662	836	305	58	10	10	10
	20362	21480	24474	25957	26625	25699	24474	23263	21539	19079	14700	11175	8056	6261	5309	2549	1139	561	98	14	10	10
	9857	9253	9423	9601	9687	8952	8371	8037	7925	7690	6141	4419	3335	2782	2469	1426	356	90	10	10	6	4
2D	13635	14806	14554	15691	16614	16889	15678	13327	11562	9889	7213	5766	5032	4375	3434	1568	999	394	64	10	10	10
	17102	18379	19637	19847	19393	18740	18297	17545	16369	15191	12218	9104	6471	5238	4598	2993	1444	664	139	33	11	10
	7284	7218	7184	7108	7039	7088	6791	6554	6407	6168	5148	4035	3299	3104	2599	1605	455	147	10	10	6	4
2.5D	9839	10396	10087	10040	10021	10273	10192	10480	9689	8494	6520	5056	4545	4116	3666	1831	1135	473	66	10	10	10
	12753	13475	13854	14354	14296	14074	13654	12781	11681	10824	8552	6833	5870	5198	4143	2588	1564	746	184	40	11	10
	5897	6084	6220	6163	5948	5666	5467	5385	5271	5101	3952	3247	2893	2589	2401	1766	746	199	27	10	4	3
3D	7318	7428	7238	7040	7124	7258	7066	6755	6744	6809	5589	4722	4213	3919	3480	2043	1201	576	82	15	9	9
	9314	9120	9483	9828	9729	9412	9107	9020	8277	7329	6939	5519	4811	4240	3669	2425	1533	780	210	51	12	11
	4521	4581	4629	4674	4695	4663	4391	4098	3918	3565	3036	2711	2494	2359	2268	1724	908	268	31	9	4	3
3.5D	5574	5481	5603	5533	5293	4978	4778	4818	4815	4562	4497	3954	3487	3026	2769	1919	1315	414	107	15	8	6
	6647	6597	6328	6275	6358	6199	6173	6028	5987	5638	5093	4684	4238	3869	3604	2328	1507	759	231	71	11	13
	3149	3119	3160	3181	3203	3193	3107	3019	2926	2808	2502	2242	2063	2015	1872	1401	911	243	36	10	5	3
4D	3837	3852	3848	3955	4069	3832	3591	3593	3632	3672	3208	2901	2546	2264	2104	1678	1111	471	124	17	10	5
	5164	4920	4610	4518	4472	4486	4358	4293	4211	4223	4215	3993	3661	3513	3233	2398	1737	763	272	71	30	17
	2452	2432	2455	2460	2457	2358	2357	2333	2241	2271	1994	1801	1679	1622	1519	1139	674	231	40	10	7	3
4.5D	2922	2897	2894	2953	3045	2981	2836	2828	2724	2582	2354	2115	1930	1830	1823	1458	1082	470	101	17	10	5
	3664	3527	3494	3452	3368	3302	3362	3580	3713	3737	3607	3280	3042	2953	2752	2219	1588	733	230	71	34	19
	1834	1835	1858	1863	1888	1840	1812	1798	1752	1719	1661	1538	1360	1310	1198	920	458	217	43	9	7	3
5D	2183	2165	2170	2177	2203	2137	2100	2071	2033	1983	1777	1619	1595	1516	1491	1216	994	496	69	18	10	5
	2596	2685	2908	2887	2856	2773	2701	2611	2574	2669	2815	2483	2311	2262	2167	1856	1416	756	248	70	37	23

Table 5

Luminous intensities (cd) for the sales-weighted sample representing the low-beam headlamps on current light trucks and vans in the U.S. The entries in each cell are (from top to bottom) the 25th percentile, the median (50th percentile), and the 75th percentile. (Test voltage 12.8 V.)

	45L	40L	35L	30L	25L	20L	15L	10L	9L	8L	7L	6L	5L	4.5L	4L	3.5L	3L	2.5L	2L	1.5L	1L	0.5L	0
7U	23	22	17	19	34	35	36	44	43	45	48	49	52	53	54	56	57	58	59	60	62	63	65
	51	51	46	42	38	38	40	54	50	53	60	59	64	64	64	64	66	70	72	72	78	82	87
	84	74	64	48	47	45	55	67	69	72	75	77	80	82	84	87	89	92	94	97	101	109	119
6.5U	23	21	17	20	35	35	38	44	46	48	50	52	54	55	57	58	60	62	64	65	67	69	70
	49	52	47	43	39	41	44	56	60	61	64	62	65	68	69	71	76	79	76	78	81	94	99
	76	74	76	49	47	45	57	70	73	75	79	81	84	86	88	91	95	99	103	106	111	118	129
6U	23	23	17	20	34	36	41	48	50	52	54	55	58	60	62	63	65	67	70	72	75	77	78
	52	59	49	45	38	43	46	60	64	67	69	67	70	72	73	75	78	81	83	84	88	104	112
	79	74	83	54	48	46	59	75	78	81	85	88	92	93	96	99	104	109	114	119	125	132	144
5.5U	22	28	18	20	29	39	44	51	53	55	57	59	61	63	66	68	69	72	76	79	81	84	87
	67	54	51	46	39	43	50	63	68	71	74	75	77	78	81	83	85	87	90	93	97	105	129
	84	75	87	50	47	47	64	81	86	90	94	97	102	104	108	112	117	122	128	135	142	150	160
5U	21	29	19	20	35	37	46	56	58	60	62	65	68	70	73	75	78	81	85	87	91	95	97
	68	69	50	44	38	45	54	69	74	76	79	81	85	87	88	90	93	95	98	101	106	115	148
	82	83	78	51	48	50	71	90	95	100	105	110	115	117	121	127	132	138	146	155	163	175	184
4.5U	19	31	19	22	35	38	50	61	63	65	68	71	75	77	80	82	86	90	95	99	103	107	110
	68	69	44	41	39	46	60	75	78	81	84	87	92	93	95	98	101	103	106	110	115	124	138
	80	87	69	50	50	53	76	101	107	113	119	124	131	135	139	144	151	158	166	177	186	194	204
4U	18	29	20	24	36	39	52	68	70	73	77	80	85	88	91	94	98	103	109	116	119	123	125
	68	64	43	41	44	49	65	80	85	87	91	94	98	100	104	106	108	112	115	119	126	135	146
	78	87	62	50	53	61	84	112	119	128	135	142	151	158	163	169	189	197	209	205	218	225	232
3.5U	17	28	21	25	37	42	56	76	79	83	86	91	96	100	104	108	113	119	125	132	138	144	147
	67	52	42	42	42	53	72	89	93	96	101	104	108	110	113	116	120	124	129	134	142	155	169
	79	87	67	52	55	61	92	125	132	142	151	158	169	175	180	187	195	205	219	235	247	261	270
3U	17	31	22	24	39	43	62	89	92	96	101	106	114	118	122	127	130	134	140	145	153	164	180
	68	51	48	40	47	58	76	96	103	105	109	113	117	120	124	130	138	147	154	166	178	186	186
	77	84	74	54	57	76	104	138	148	157	166	175	187	195	202	210	222	250	261	278	303	330	323
2.5U	17	27	22	25	39	49	71	102	105	108	114	119	126	128	129	134	139	144	149	152	160	171	186
	61	51	49	41	49	65	82	103	109	119	121	125	135	140	146	155	166	184	203	214	233	238	240
	77	83	87	55	64	79	115	156	165	174	186	198	213	221	232	242	255	273	315	347	364	390	424
2U	16	25	22	25	38	53	88	117	127	124	139	141	147	149	152	155	160	164	168	175	181	187	200
	41	60	50	41	51	72	92	126	130	138	146	155	170	180	193	207	232	276	286	307	317	321	335
	79	87	82	63	67	78	135	176	186	199	212	226	252	267	288	302	314	345	362	398	420	450	486
1.5U	17	24	21	26	39	64	94	141	149	160	162	165	174	175	179	183	190	198	206	212	222	236	250
	40	73	50	41	48	83	112	153	160	170	183	196	219	233	248	280	325	354	401	446	458	470	498
	77	89	68	60	73	92	183	239	252	270	288	319	336	345	354	373	392	411	436	483	506	551	605
1U	15	20	21	26	39	68	109	169	183	203	206	211	213	215	216	229	244	253	262	270	282	314	350
	40	70	45	41	51	84	145	194	204	222	238	260	295	321	364	417	436	480	552	620	714	747	845
	76	104	72	62	80	112	203	273	282	297	314	341	374	391	409	454	535	606	661	758	778	843	982
0.5U	14	20	21	26	39	86	150	211	235	290	316	341	350	353	361	367	370	380	400	432	462	570	713
	39	72	46	41	53	103	180	281	301	338	351	394	457	472	491	529	616	703	788	890	934	1037	1206
	79	88	74	67	100	139	264	332	333	350	370	407	473	532	622	732	843	940	1071	1198	1391	1709	2381
0	11	13	14	15	32	96	245	316	371	479	505	553	599	624	659	693	738	824	873	964	1074	1389	2187
	36	56	45	42	62	132	286	463	501	564	596	655	765	794	841	917	1018	1121	1262	1427	1559	1875	2507
	80	88	79	63	120	188	544	718	729	732	735	746	816	920	1053	1199	1386	1561	1819	2089	2496	3364	5058
0.5D	10	10	10	13	32	126	392	570	637	697	746	814	893	942	991	1050	1128	1244	1456	1805	2420	3543	5383
	31	61	34	32	75	210	486	779	864	976	1056	1153	1446	1682	1703	1755	1822	2011	2340	2588	2956	4039	6863
	74	87	74	57	163	247	955	1620	1608	1635	1655	1679	1733	1856	2050	2235	2488	2839	3335	4014	5363	8079	11787
1D	10	10	10	14	44	243	622	1022	1071	1136	1202	1282	1383	1443	1523	1608	1743	1941	2358	3164	4684	6688	10595
	29	71	41	50	126	340	896	1196	1370	1645	1889	2167	2782	2999	3222	3443	3827	4241	4695	5588	7203	9176	11672
	69	101	82	64	244	422	1976	2184	2303	2375	2516	2785	3338	3605	3889	4407	5164	6080	7234	8507	10504	14227	18846
1.5D	10	10	10	31	66	474	1149	1616	1699	1771	1870	2008	2186	2275	2385	2537	2796	3256	4176	5703	7348	10489	14955
	29	72	51	57	203	553	1360	1979	2247	2563	3051	3560	4040	4245	4349	4680	5570	6687	8000	10230	13120	15408	18513
	69	118	86	72	378	704	2642	2818	2983	3109	3284	3630	4389	4919	5680	6660	7859	9397	11266	13352	16139	19971	23457
2D	10	10	11	33	100	695	1770	2408	2545	2663	2864	3097	3215	3342	3501	3770	4202	4737	5491	6654	8705	12205	13983
	31	56	45	71	317	869	2019	2787	2990	3349	3710	3955	4541	4885	5455	6217	7011	8007	9790	11599	13749	16403	18873
	70	125	99	96	647	1151	2445	3201	3444	3633	3958	4332	5203	5965	7103	8127	9368	10993	12914	14741	17343	19439	22101
2.5D	10	10	13	36	133	855	2120	2963	3039	3171	3315	3489	3724	3852	4035	4398	4887	5543	6179	7167	8542	10456	12511
	29	66	44	81	368	1107	2413	3100	3280	3596	3820	4192	4678	4805	5115	5640	6394	7225	8559	10769	12026	13993	15778
	60	111	84	122	785	1483	2611	3357	3563	3883	4249	4758	5433	6075	7311	7614	8601	9869	11895	13001	14281	15595	18056
3D	10	10	17	39	144	707	1941	2756	2930	3161	3208	3338	3542	3665	3809	4000	4269	4615	5746	6157	6868	7511	8029
	29	87	67	104	386	1267	2441	3133	3288	3444	3651	3978	4365	4680	4945	5264	5762	6461	7357	8411	9503	11203	11879
	60	117	83	165	877	1710	2754	3475	3631	4000	4360	4751	5161	6826	6903	7068	7412	8145	9405	11403	11237	12320	13964
3.5D	10	13	26	42	161	432	1545	2189	2339	2502	2641	2745	2883	3002	3119	3240	3404	3602	3814	4037	4193	4421	4660
	36	48	63	97	223	1260	2284	2594	2664	2772	2915	3104	3394	3507	3679	3989	4428	5032	5748	6445	7226	8005	7923
	62	89	80	196	894	1645	2366	3433	3589	3550	3779	4557	4857	5095	6405	6459	6624	7011	7599	8348	8223	9013	9657
4D	15	21	25	40	134	255	1282	1748	1812	1876	1935	1989	2053	2093	2144	2216	2285	2363	2494	2647	2720	2747	2736
	55	67	65	104	174	1158	1800	2043	2098	2180	2355	2561	2755	2862	3003	3247	3601	4058	4586	5074	5951	5962	5932
	62	79	82	162	916	1619	2097	2755	2800	2871	3072	3330	3850	4616	4779	4948	5102	5745	5875	5862	6133	6314	6700
4.5D	17	22	27	38	102	172	1028	1291	1342	1374	1412	1459	1496	1533	1554	1582	1635	1680	1730	1816	1887	1911	1898
	55	63	64	91	157	926	1451	1662	1728	1791	1877	2024	2198	2329	2410	2534	2659	2902	3198	3224	3255	3262	3331
	65	79	85	166	868	1471	1772	2135	2194	2241	2373	2530	2729	2885	3092	3279	3470	3624	3793	4082	4338	4364	4375
5D	15	21	24	41	85	137	696	974	988	988	1024	1064	1113	1125	1146	1157	1188	1215	1247	1285	1321	1400	1426
	54	60	67	80	154	691	1156	1331	1379	1433	1481	1543	1651	1715	1721	1765	1863	2017	1999	2036	2082	2149	2234
	65	80	81	222	770	1259	1431	1642	1698	1762	1832	1952	2071	2138	2193	2268	2372	2512	2706	3028	3053	3063	3065

	0.5R	1R	1.5R	2R	2.5R	3R	3.5R	4R	4.5R	5R	6R	7R	8R	9R	10R	15R	20R	25R	30R	35R	40R	45R
	66	67	67	68	67	67	66	65	63	62	59	57	55	53	52	43	34	27	19	15	10	12
7U	93	98	102	103	103	98	94	90	84	80	72	67	68	64	61	49	48	31	23	18	16	14
	132	144	149	149	144	134	124	116	109	105	100	93	88	85	82	74	61	43	29	21	18	16
	72	72	73	74	74	73	72	71	70	68	64	61	59	57	55	45	35	28	18	16	10	12
6.5U	105	108	110	110	108	107	103	97	91	86	80	74	70	66	64	51	46	30	22	18	16	13
	144	160	168	171	161	156	142	132	124	119	111	105	100	96	91	81	68	46	30	22	19	16
	79	80	81	81	80	80	78	77	75	74	70	67	64	62	59	50	38	29	18	17	10	11
6U	115	119	123	124	123	121	118	112	106	100	90	80	74	71	67	55	47	31	22	18	16	12
	161	184	179	179	174	174	164	149	140	134	124	118	110	105	100	86	72	44	31	23	21	16
	88	89	90	90	90	89	87	86	84	82	78	74	71	68	64	54	42	32	18	17	10	11
5.5U	134	140	142	143	140	136	131	124	118	112	100	92	87	82	79	56	49	33	23	18	16	12
	174	195	216	211	208	205	190	172	162	155	144	135	128	120	115	98	77	47	30	24	25	16
	99	100	100	99	98	97	95	94	92	90	85	81	76	73	69	57	45	30	18	14	11	8
5U	153	159	166	169	166	161	155	148	140	134	122	114	105	106	96	68	52	33	24	18	16	12
	198	204	231	243	239	240	217	200	188	179	163	153	143	134	128	109	85	49	31	23	22	17
	112	112	113	114	113	111	110	107	105	102	96	90	85	81	75	62	49	35	19	14	14	9
4.5U	177	187	192	196	193	187	182	172	166	159	146	134	124	121	117	77	54	36	24	18	15	12
	219	231	244	257	262	261	248	232	225	214	194	180	170	164	151	121	96	55	33	23	22	17
	127	130	131	132	131	129	128	124	122	118	110	102	94	88	83	66	52	32	21	14	12	9
4U	163	208	218	222	223	221	214	207	195	184	166	156	141	135	129	93	61	38	25	20	17	12
	246	257	271	280	285	287	277	273	260	254	233	216	198	185	165	136	98	58	36	25	24	17
	149	152	154	154	153	152	151	148	143	139	129	118	110	102	94	72	56	35	22	15	12	9
3.5U	185	208	250	255	253	245	232	221	212	203	184	175	163	158	150	102	69	40	26	22	18	13
	274	291	302	311	318	316	312	310	304	295	278	254	224	194	177	146	110	63	37	27	27	18
	180	182	183	183	182	185	181	177	170	164	148	136	126	116	107	80	61	35	21	16	12	11
3U	202	223	237	252	257	287	276	261	247	239	217	201	188	177	172	123	82	46	30	23	18	14
	337	346	362	365	364	359	355	359	356	347	322	306	239	210	194	160	114	67	37	28	27	20
	206	228	245	233	230	226	223	220	216	207	182	162	146	135	124	90	68	36	24	17	11	9
2.5U	250	256	258	271	279	284	285	286	275	264	240	227	217	208	173	128	92	51	28	24	18	14
	415	422	434	456	454	453	446	422	463	426	377	311	251	228	208	171	121	76	40	30	29	20
	220	242	261	278	288	294	301	278	275	261	233	200	173	158	143	102	76	39	23	18	12	10
2U	352	362	363	358	348	330	315	314	312	310	299	282	259	231	201	141	99	59	28	23	19	15
	528	560	607	576	579	584	612	675	532	499	406	336	286	265	259	191	139	80	42	30	31	18
	272	299	324	347	359	361	359	366	364	354	302	268	220	194	172	119	85	46	25	18	12	10
1.5U	527	544	553	554	541	503	475	434	398	371	344	326	297	262	230	156	111	65	30	22	17	14
	658	705	747	771	771	792	908	844	660	570	464	411	396	356	343	234	156	88	45	29	36	17
	395	442	499	555	610	679	731	617	571	517	477	405	288	247	220	143	97	55	27	18	12	9
1U	948	1007	1036	925	882	850	772	751	730	655	495	418	367	318	275	185	128	73	31	23	18	15
	1082	1138	1161	1185	1233	1295	1304	1193	1061	935	818	653	537	472	405	276	196	98	50	31	40	20
	928	1136	1327	1560	1761	1988	1905	1477	1220	976	731	595	397	329	291	178	112	64	29	19	11	9
0.5U	1453	1710	1899	2076	2284	2322	2075	1839	1654	1399	914	663	519	441	376	220	153	89	32	24	17	15
	2924	3046	2958	2851	2738	2510	2288	2110	1887	1606	1165	911	874	704	539	357	261	124	56	31	42	22
	2905	3789	4264	4623	4773	4769	4599	3892	2927	1633	1083	860	646	523	436	249	141	66	29	11	10	10
0	3758	4840	5794	6258	6312	6264	5794	4356	3163	2559	1720	1318	990	742	659	313	189	106	32	14	11	10
	6431	7079	7642	7832	7716	7113	5907	5739	4704	3951	2567	1634	1548	1145	844	602	380	144	60	27	43	25
	7993	9970	11127	11749	12030	10731	8931	7343	5148	4055	2311	1408	1033	813	662	359	189	80	30	10	8	10
0.5D	9675	13005	14841	14038	13563	13341	12155	9172	7095	4967	2999	2524	1821	1239	1035	515	292	135	30	14	10	10
	14245	15228	15685	16629	16280	15085	14266	13235	11267	9885	6149	3607	2669	1818	1462	937	632	254	83	23	33	13
	14170	16417	17746	17532	18175	17082	14519	11742	8687	7433	5068	3171	2242	1394	1086	566	260	101	33	11	10	10
1D	16265	20580	21131	20482	20484	19690	21035	17460	13522	9941	5911	4312	3155	2248	1955	927	513	216	42	18	10	10
	21241	22000	24068	25831	25693	24454	22776	21065	18035	15496	10108	6095	4205	2929	2269	1459	1086	339	106	31	36	17
	18033	20186	22011	23873	24528	22813	20904	17982	14336	10562	7880	5657	4666	2515	1832	845	419	146	34	11	10	10
1.5D	22182	24893	26663	25871	25594	25924	23939	19858	16762	14605	10482	6884	4868	3772	3253	1769	891	260	50	30	10	10
	25878	27020	27658	29333	30142	30117	28677	26016	22207	19116	13457	8264	5243	4626	4231	2366	1585	504	126	34	47	17
	16100	19363	22166	23740	24571	23169	20302	18356	16380	14333	9259	6778	5509	3968	3128	1379	632	204	36	11	10	10
2D	21753	24106	24993	25513	25215	24491	23409	22318	20776	17997	13079	9038	6397	5157	4419	3122	1448	338	57	24	11	11
	24586	26133	27609	27488	30148	29265	28113	25431	21928	18851	14128	9941	6765	5271	4966	3363	2137	518	157	37	47	20
	13114	14134	15012	15619	16296	16040	15358	14282	13135	11921	9914	6252	5807	5670	4273	2506	988	283	53	11	10	10
2.5D	17610	19297	20124	19533	19367	19419	18689	17515	16297	14305	10769	9023	7108	5887	5072	3416	1981	423	69	18	11	11
	20432	21333	22081	23906	23907	23299	22047	20282	18101	16095	12466	9806	7545	6094	5723	4490	2726	613	177	45	49	20
	8434	8718	9011	9262	9407	9432	9270	8876	8373	7780	6884	5942	5547	5515	4500	3265	1402	376	60	13	10	10
3D	11850	13221	15508	16001	16508	16803	12224	12521	11368	10371	8915	7392	6531	5795	5396	4473	1844	648	82	20	11	11
	15153	15596	16143	17007	17498	17376	17070	15701	14189	12709	9482	7851	6639	5889	5575	4589	3528	876	227	56	61	20
	4908	5104	5205	5210	5244	5301	5264	5102	4845	4672	4480	4289	4198	4082	3673	3385	1879	434	57	17	10	9
3.5D	8880	8945	9046	9152	9164	9181	9275	9247	8982	8421	6929	5845	5251	4851	4561	4176	2698	882	97	29	18	10
	10056	10819	11155	11274	11290	11288	11197	11112	10677	9782	7830	7114	5871	5338	5295	5236	3466	1207	328	65	62	19
	2805	2963	3098	3214	3299	3281	3143	3083	2959	2881	2758	2693	2662	2582	2487	2695	1575	321	52	26	11	9
4D	5944	5975	6020	6042	6016	5947	5874	5765	5705	5651	5645	4481	4085	3861	3691	3494	2953	1263	93	33	18	10
	7075	7228	7320	7416	7605	7733	7828	7670	7373	7119	6428	5590	5377	5217	5168	4464	3597	1584	447	71	53	25
	1887	1949	1964	2000	2041	1997	1951	1940	1930	1927	1918	1888	1853	1826	1802	2024	1227	255	47	32	14	9
4.5D	4216	4213	4218	4246	4252	4201	4157	4051	3985	3977	4050	4039	3221	3107	3012	2796	2542	1257	122	38	18	12
	4493	4613	4728	4869	5010	5114	5162	5194	5191	5175	5189	4792	4715	4666	4481	3808	3684	2288	568	82	52	25
	1425	1434	1469	1495	1495	1449	1458	1456	1446	1449	1437	1383	1346	1346	1319	1452	946	195	52	33	16	9
5D	2307	2376	2434	2933	2925	2900	2895	2849	2822	2845	2914	2884	2465	2424	2377	2099	1968	1118	142	57	18	15
	3074	3069	3078	3121	3179	3235	3304	3371	3437	3498	3710	3685	3550	3547	3587	3918	3093	2082	668	125	64	30

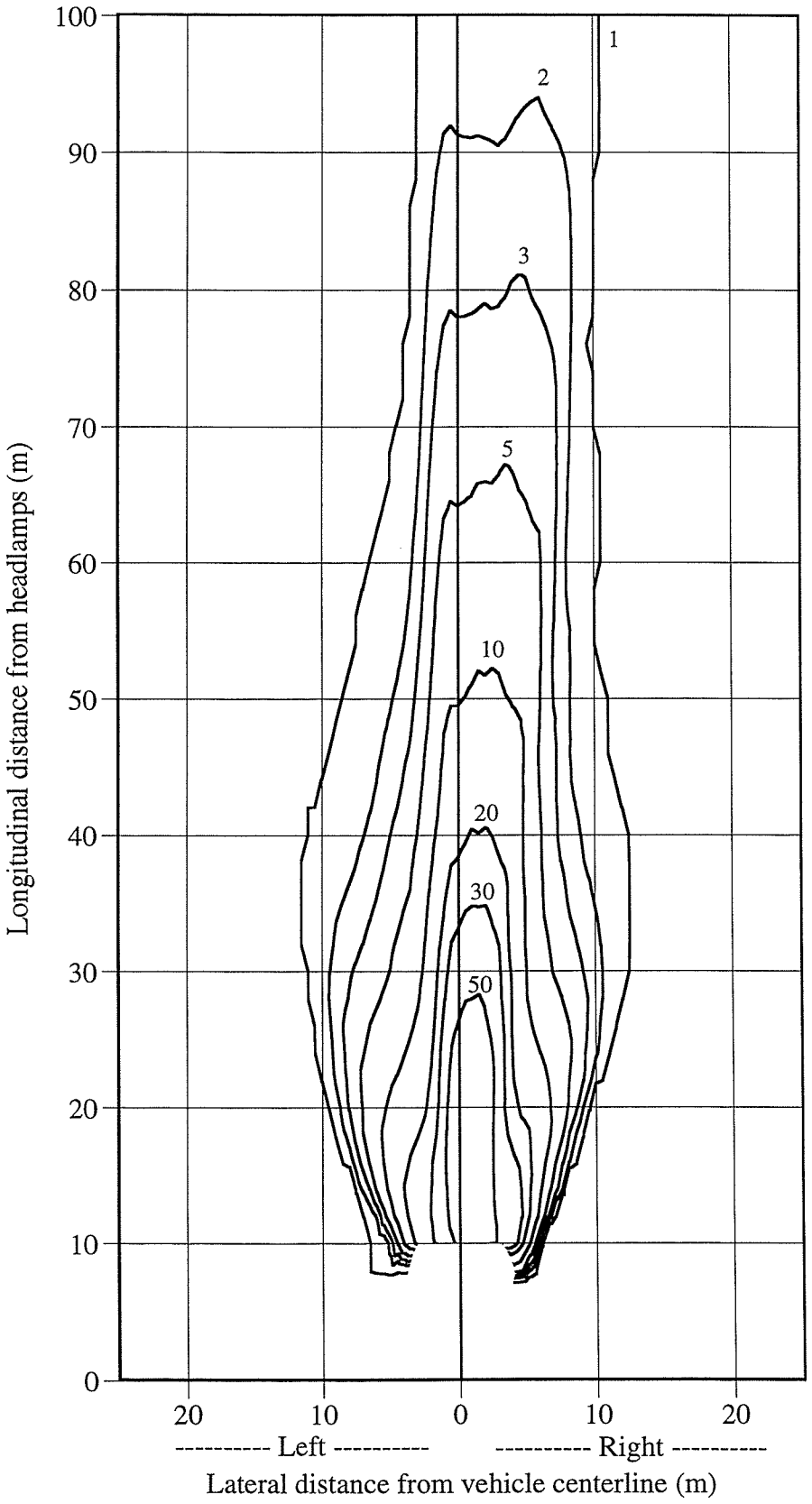

Figure 5. Isoilluminance diagram (in vertical lux) at the road surface from a pair of lamps having the median (50th percentile) luminous intensities for the sales-weighted sample representing the low-beam headlamps on current light trucks and vans in the U.S. (Test voltage 12.8 V, lamp mounting height 0.83 m, and lamp separation 1.30 m.)

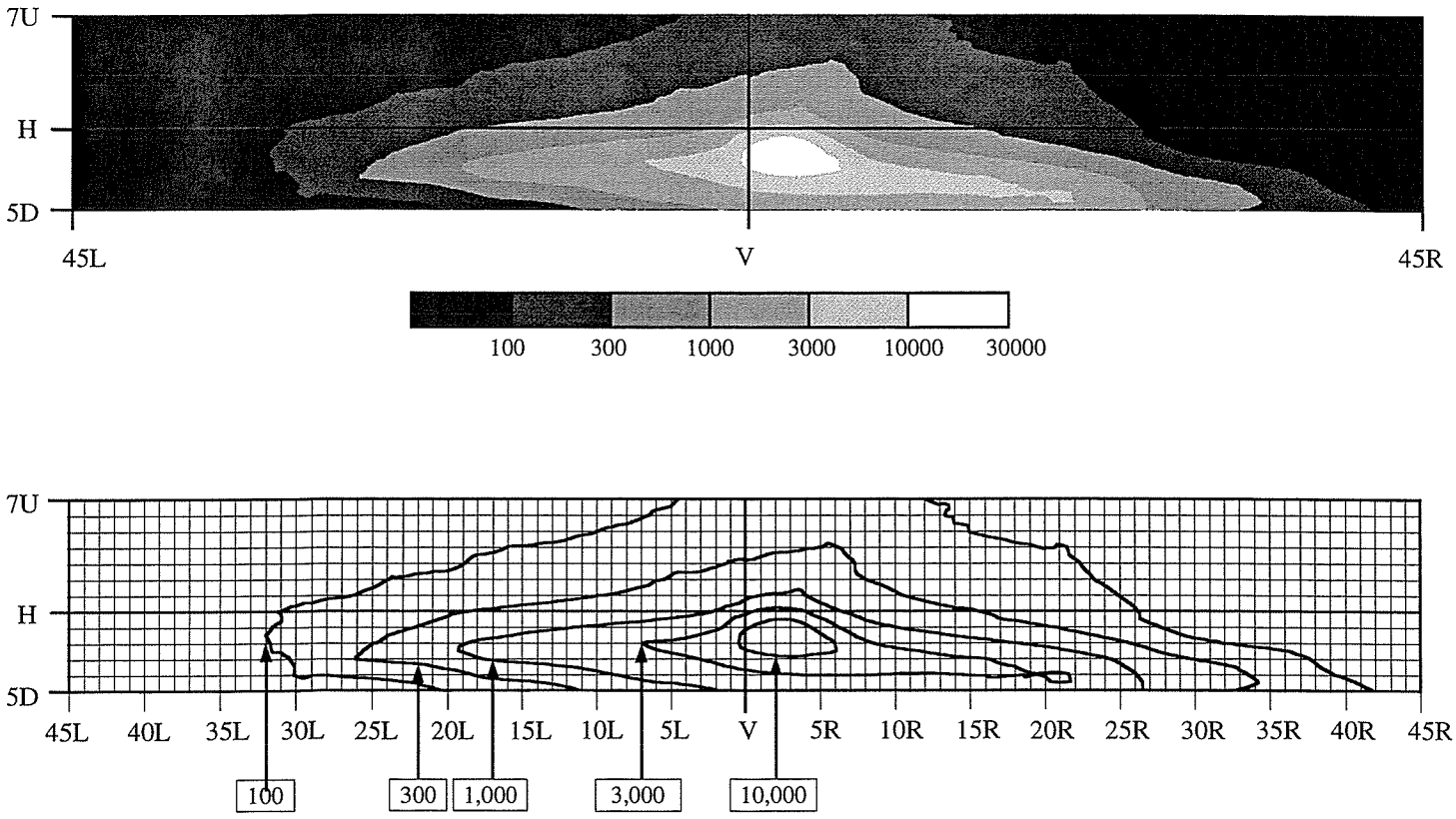

Figure 6. Isocandela diagrams of the median (50th percentile) luminous intensities for the sales-weighted sample representing the low-beam headlamps on current vehicles that use the HB1 (9004) light source in the U.S. The two panels represent the same information in different formats. (Test voltage 12.8 V.)

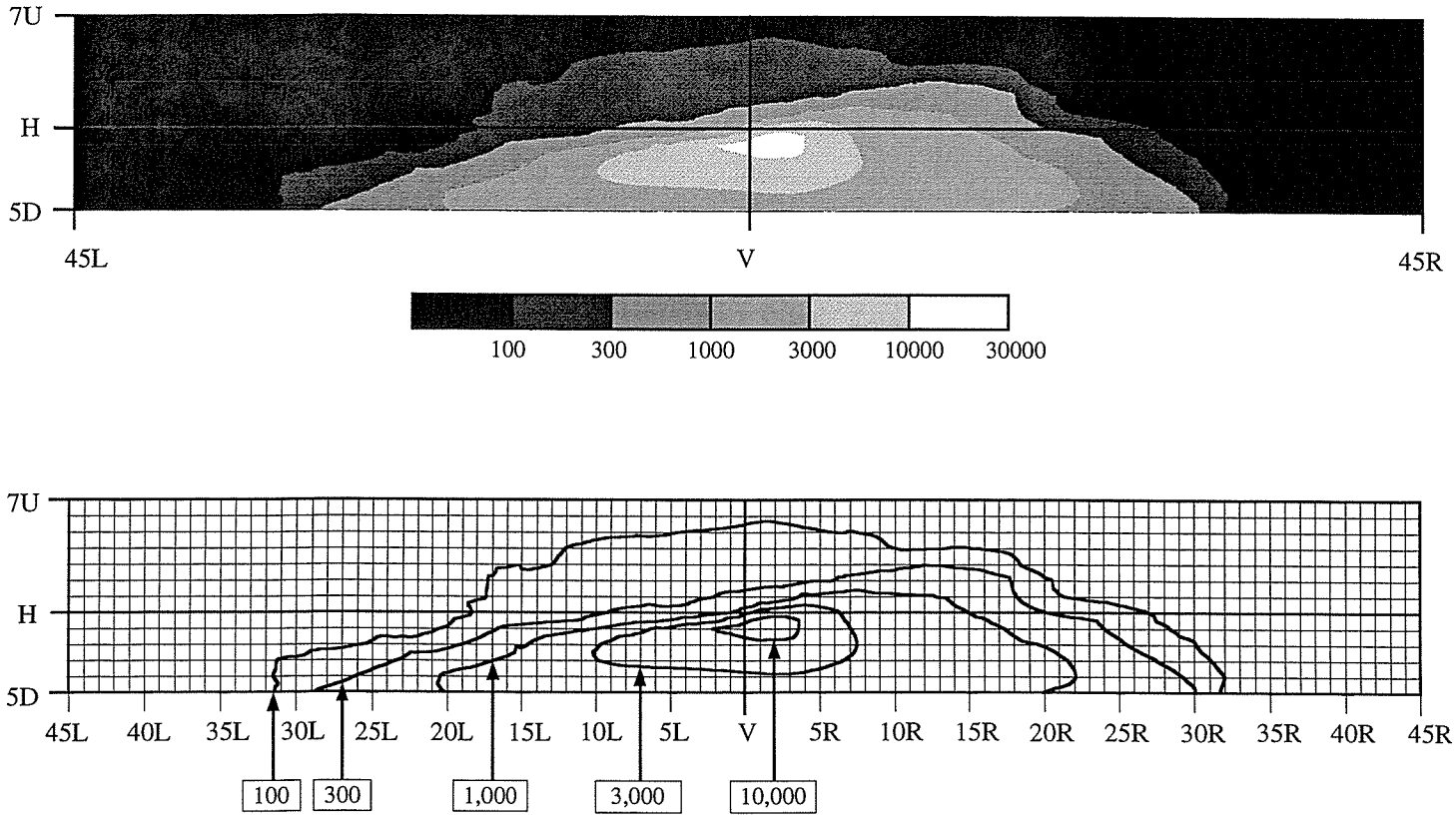

Figure 7. Isocandela diagrams of the median (50th percentile) luminous intensities for the sales-weighted sample representing the low-beam headlamps on current vehicles that use the HB2 (H4) light source in the U.S. The two panels represent the same information in different formats. (Test voltage 12.8 V.)

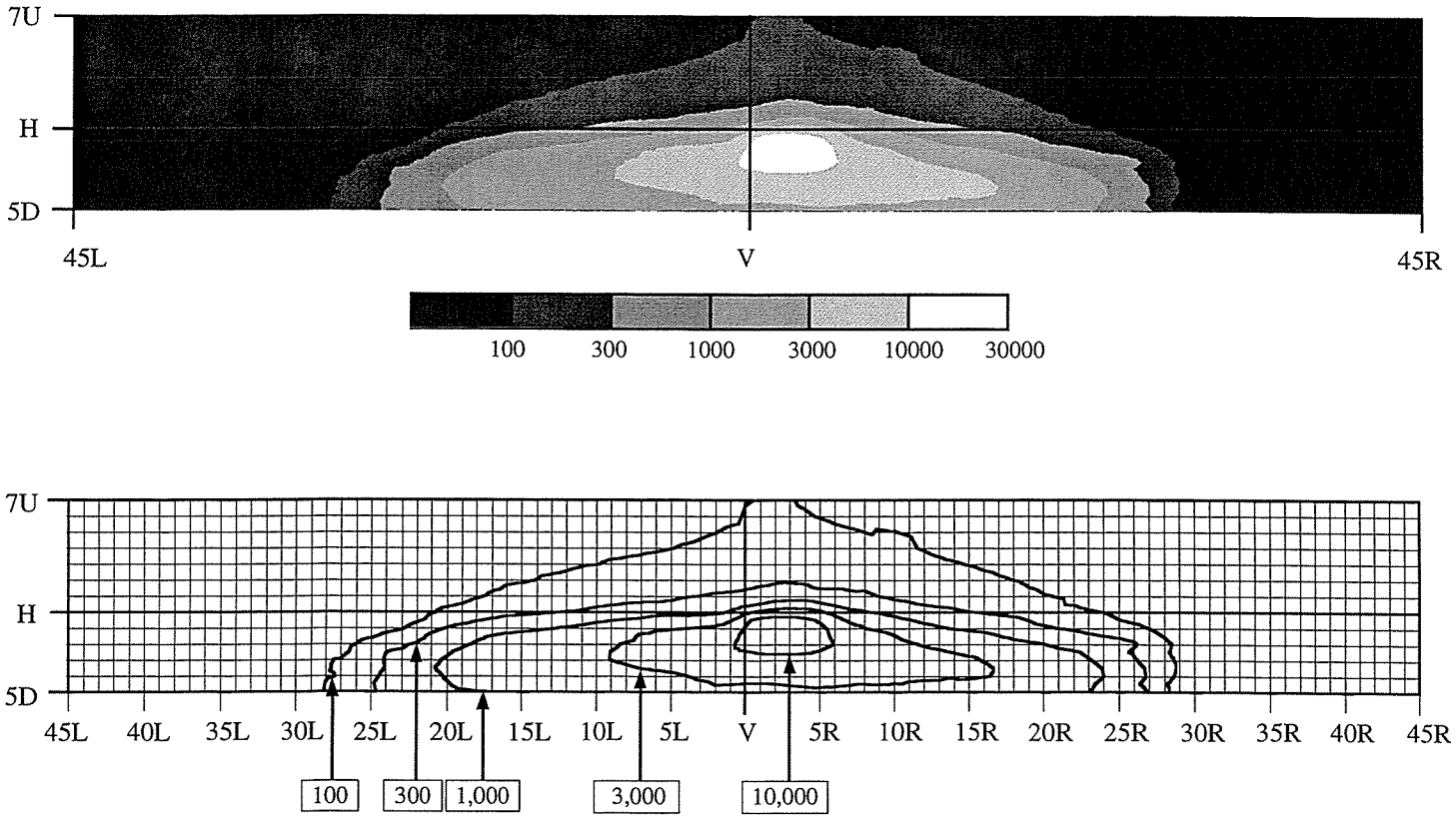

Figure 8. Isocandela diagrams of the median (50th percentile) luminous intensities for the sales-weighted sample representing the low-beam headlamps on current vehicles that use the HB4 (9006) light source in the U.S. The two panels represent the same information in different formats. (Test voltage 12.8 V.)

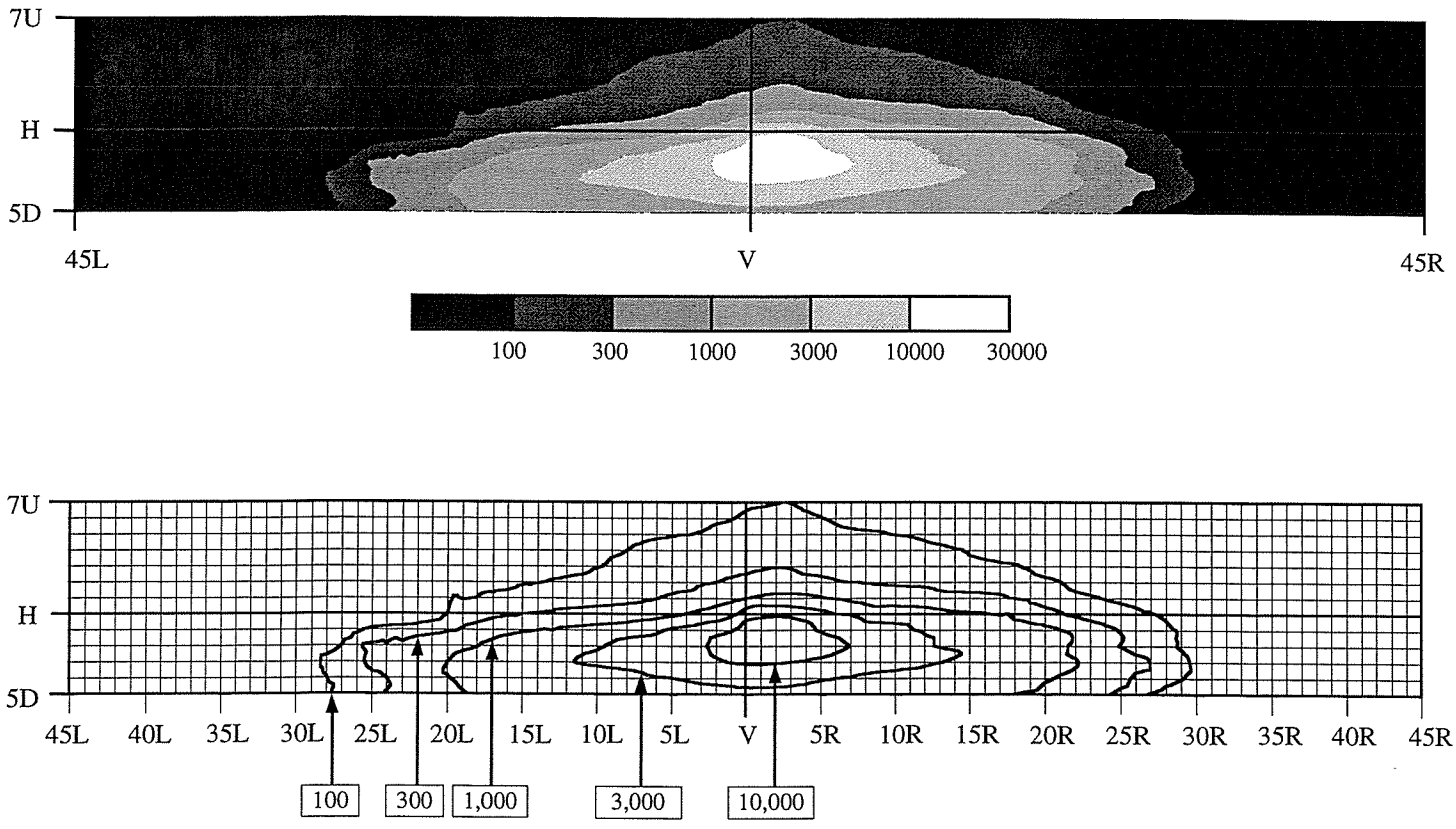

Figure 9. Isocandela diagrams of the median (50th percentile) luminous intensities for the sales-weighted sample representing the low-beam headlamps on current vehicles that use the HB5 (9007) light source in the U.S. The two panels represent the same information in different formats. (Test voltage 12.8 V.)

Table 6
Luminous intensities (cd) for the sales-weighted sample representing the low-beam headlamps on current vehicles in the U.S. that use the HB1 (9004) light source. The entry in each cell is the median (50th percentile). (Test voltage 12.8 V.)

	45L	40L	35L	30L	25L	20L	15L	10L	9L	8L	7L	6L	5L	4.5L	4L	3.5L	3L	2.5L	2L	1.5L	1L	0.5L	0
7U	40	50	45	44	44	46	62	76	79	82	89	91	95	100	104	107	110	112	119	145	155	138	151
6.5U	35	46	43	45	44	49	64	80	84	87	91	96	100	104	109	112	118	142	145	154	146	158	163
6U	33	44	44	47	45	51	69	86	90	95	97	105	108	111	117	122	146	149	151	159	173	157	160
5.5U	32	44	43	44	47	55	73	92	95	99	104	114	122	126	132	154	157	160	168	176	188	169	180
5U	30	41	42	43	50	59	81	100	105	108	114	122	151	157	160	163	166	169	178	187	198	215	235
4.5U	30	39	42	46	55	64	89	107	113	118	126	135	169	173	174	178	182	189	198	213	229	252	274
4U	30	37	43	46	57	70	101	117	122	127	134	146	184	188	192	195	199	206	218	233	250	272	299
3.5U	28	38	43	47	70	77	114	131	136	141	148	168	211	214	216	219	223	232	246	265	249	260	269
3U	28	40	50	47	73	86	127	147	153	159	168	193	235	241	248	254	258	264	273	287	311	338	312
2.5U	27	36	47	52	83	100	158	168	174	180	191	217	285	294	293	291	297	311	329	360	377	403	437
2U	25	35	45	57	89	134	179	222	233	245	230	292	315	338	353	357	356	364	381	417	439	470	507
1.5U	24	32	47	66	98	150	200	253	266	282	301	334	353	364	375	397	415	432	456	502	528	574	629
1U	22	29	54	81	112	177	231	296	305	318	335	363	401	420	438	456	477	503	548	590	645	730	829
0.5U	23	31	63	95	136	210	278	353	365	385	403	430	456	473	494	536	580	621	667	749	825	959	1148
0	25	36	68	113	172	266	373	507	535	564	592	646	695	721	756	792	842	917	1046	1210	1489	1574	2006
0.5D	18	27	59	114	176	317	528	731	785	837	887	966	1046	1094	1144	1212	1300	1419	1623	1941	2725	3871	5169
1D	17	30	65	121	202	416	740	1091	1178	1240	1323	1429	1547	1607	1692	1808	1977	2195	2469	3000	4204	6396	8809
1.5D	17	32	69	130	239	579	1062	1603	1747	1860	2037	2200	2380	2474	2598	2809	3084	3428	3880	4710	6557	9330	12268
2D	17	32	74	120	287	856	1626	2495	2635	2756	2964	3205	3331	3470	3661	3980	4463	4879	5296	6031	7414	9609	12286
2.5D	16	28	66	117	357	849	1813	2289	2443	2583	2754	2955	3192	3332	3515	3870	4303	4772	5367	6918	8432	8625	9570
3D	16	24	55	109	350	613	1287	1778	1931	2076	2211	2351	2544	2631	2737	2885	3065	3279	3542	3958	4540	5250	5941
3.5D	16	20	44	101	197	363	782	1269	1450	1608	1734	1852	1979	2048	2130	2224	2343	2482	2652	2861	3114	3409	3708
4D	16	18	39	103	115	204	435	822	987	1122	1245	1351	1422	1461	1514	1570	1638	1723	1813	1909	2010	2136	2257
4.5D	27	31	62	82	88	134	274	576	697	797	904	992	1031	1052	1084	1121	1166	1220	1277	1334	1385	1439	1501
5D	27	36	66	71	73	104	180	385	488	564	634	702	755	778	809	848	891	936	990	1038	1082	1127	1172

	0.5R	1R	1.5R	2R	2.5R	3R	3.5R	4R	4.5R	5R	6R	7R	8R	9R	10R	15R	20R	25R	30R	35R	40R	45R
7U	156	157	153	148	144	136	131	129	126	127	131	123	115	120	112	92	69	55	28	20	16	10
6.5U	167	161	156	150	141	137	135	136	137	138	148	139	144	127	120	85	73	62	27	20	15	10
6U	161	161	156	155	151	152	151	153	158	159	168	182	159	139	131	92	76	64	29	21	15	10
5.5U	183	183	189	184	181	179	180	185	185	186	193	190	167	148	137	94	80	62	29	21	15	10
5U	214	225	218	213	208	210	208	207	212	212	248	214	188	164	149	99	85	64	30	23	16	12
4.5U	292	256	250	243	241	237	235	238	239	252	263	230	201	173	158	108	88	61	30	22	15	12
4U	265	264	263	265	264	267	271	283	282	294	305	270	234	195	174	137	98	65	32	23	16	12
3.5U	274	290	303	312	321	324	335	343	401	374	334	287	236	204	187	148	108	66	33	23	16	12
3U	324	342	357	370	379	382	386	395	458	425	372	322	252	221	205	162	117	72	36	23	15	11
2.5U	403	422	443	447	446	448	446	459	486	449	405	334	266	241	219	176	138	76	37	24	16	12
2U	547	579	625	558	561	568	607	699	561	532	444	359	301	273	250	187	144	81	37	23	14	10
1.5U	682	728	770	790	791	823	939	878	697	605	506	414	347	312	279	214	157	92	42	24	15	10
1U	914	983	1041	1071	1073	1105	1144	973	829	721	571	479	411	360	317	239	167	98	45	26	15	9
0.5U	1380	1572	1704	1810	1797	1757	1661	1430	1202	1005	762	610	509	434	376	270	198	111	51	28	16	10
0	2930	3521	4017	4296	4207	3966	3604	2925	2080	1574	1095	844	649	537	453	312	222	125	56	31	17	10
0.5D	6416	7788	9040	9764	9781	9522	8291	6109	4324	3289	1965	1355	952	771	651	351	242	134	51	25	16	11
1D	10891	12928	14662	16209	16790	16943	15498	12203	9011	6462	3333	2123	1456	1170	1001	549	308	176	60	30	17	12
1.5D	15442	18612	21689	20769	22078	25960	24161	20454	15388	10887	5595	3325	2170	1735	1517	844	472	220	77	41	22	14
2D	15857	16115	18724	20716	22117	22743	22686	21141	18431	15809	9873	5288	3379	2760	2418	1339	801	332	137	68	30	15
2.5D	10590	12140	13734	14955	15909	16128	15476	14250	12814	11834	10356	5927	4254	3654	3397	2224	1211	503	211	118	43	18
3D	6453	6896	7499	7998	8410	8554	8363	8099	7788	7657	7539	6193	5094	4512	4057	3096	2076	818	296	161	60	21
3.5D	4026	4342	4557	4708	4934	5122	5185	5198	5197	5190	5203	5674	4578	4213	4312	3483	2811	1101	352	214	74	26
4D	2407	2547	2666	2771	2866	2970	3056	3144	3203	3219	3183	3154	3138	3073	2921	3087	3028	1572	358	252	87	30
4.5D	1575	1640	1682	1722	1775	1849	1901	1956	1970	1979	2028	2076	2099	2118	2103	2393	2952	1908	360	277	118	37
5D	1218	1253	1283	1306	1341	1376	1420	1451	1461	1465	1478	1502	1516	1538	1543	1733	1883	1963	308	260	143	54

Table 7
Luminous intensities (cd) for the sales-weighted sample representing the low-beam headlamps on current vehicles in the U.S. that use the HB2 (H4) light source. The entry in each cell is the median (50th percentile). (Test voltage 12.8 V.)

	45L	40L	35L	30L	25L	20L	15L	10L	9L	8L	7L	6L	5L	4.5L	4L	3.5L	3L	2.5L	2L	1.5L	1L	0.5L	0
7U	9	11	16	27	34	36	42	48	47	45	44	46	48	49	49	49	50	50	50	51	52	54	58
6.5U	10	12	17	30	31	39	45	51	51	51	50	52	53	53	54	54	54	54	55	56	58	60	64
6U	9	23	17	28	31	40	48	55	55	56	56	57	59	59	59	60	61	62	64	66	69	73	77
5.5U	10	21	26	30	31	42	54	61	62	63	68	70	76	77	77	79	81	82	84	87	91	94	99
5U	19	21	26	30	31	43	57	73	80	88	91	89	96	99	102	104	106	107	110	113	116	119	123
4.5U	18	21	26	32	32	45	65	101	111	111	110	110	119	123	125	128	126	121	124	129	133	136	143
4U	18	20	26	30	32	47	73	124	128	134	131	130	134	139	137	138	137	130	133	135	139	148	156
3.5U	18	20	25	33	34	50	82	147	154	159	157	157	153	154	147	144	140	139	138	144	146	155	167
3U	18	20	26	31	32	52	91	152	158	163	165	166	170	176	162	154	142	142	139	142	152	178	182
2.5U	10	20	27	32	34	55	104	160	163	167	173	174	176	182	182	166	167	159	156	158	188	189	193
2U	17	18	27	32	34	57	164	163	168	168	174	182	185	192	196	196	202	207	214	211	210	211	217
1.5U	16	18	27	40	33	58	172	176	180	183	189	196	203	208	214	216	221	235	248	261	263	271	286
1U	17	18	27	41	35	60	175	197	210	216	219	226	234	241	243	251	268	280	302	333	359	358	363
0.5U	9	9	13	25	47	64	165	217	238	261	279	287	273	277	295	328	367	394	417	428	456	499	556
0	5	6	12	30	50	67	185	264	315	366	397	425	426	445	487	549	638	720	803	875	973	1208	2250
0.5D	10	10	10	26	50	67	196	379	541	681	777	823	1081	1241	1617	1510	1779	2172	2558	3062	5510	5515	7829
1D	10	10	10	25	60	113	425	994	1265	1702	2377	3372	3769	4896	6016	7143	8196	9260	10333	11578	12619	14624	16612
1.5D	10	10	10	25	78	128	733	2137	2645	3161	3577	4352	5967	7118	7492	7756	7831	8079	8108	8301	8727	9591	10733
2D	11	13	26	45	116	196	871	2864	3319	3633	3856	4137	4720	5116	5728	5665	5659	5664	5747	5862	6032	6283	6684
2.5D	18	18	26	68	173	416	1149	3081	3443	3802	4100	4319	4366	4360	4366	4372	4371	4422	4479	4555	4667	4838	5008
3D	16	17	26	121	220	735	1566	2966	3190	3388	3486	3541	3565	3577	3584	3597	3608	3647	3706	3780	3868	3966	4032
3.5D	16	17	28	156	284	877	1924	2594	2758	2838	2885	2932	2969	2982	2999	3029	3053	3092	3116	3148	3189	3241	3287
4D	18	17	28	193	347	1089	1873	2191	2255	2311	2356	2419	2470	2501	2524	2546	2554	2583	2595	2603	2634	2675	2685
4.5D	19	18	29	227	423	1113	1642	1804	1868	1921	1964	2042	2083	2108	2132	2149	2151	2165	2170	2179	2199	2226	2236
5D	22	19	30	260	461	1027	1402	1516	1579	1633	1674	1735	1770	1789	1799	1809	1811	1829	1835	1834	1858	1879	1869

	0.5R	1R	1.5R	2R	2.5R	3R	3.5R	4R	4.5R	5R	6R	7R	8R	9R	10R	15R	20R	25R	30R	35R	40R	45R
7U	61	63	64	63	61	58	57	55	55	55	54	53	52	50	50	43	30	20	12	5	4	2
6.5U	68	70	70	70	67	65	63	62	61	61	59	58	57	55	53	46	30	20	12	5	4	2
6U	82	85	86	85	82	79	77	76	74	72	69	67	65	62	58	51	31	23	13	6	4	2
5.5U	104	107	108	106	102	99	96	92	90	88	83	82	78	72	66	55	32	23	13	6	4	2
5U	128	130	130	127	122	118	115	111	107	104	100	102	97	85	77	61	36	29	14	6	4	2
4.5U	148	152	153	149	145	145	141	137	133	129	123	115	106	103	85	65	39	27	14	7	4	2
4U	164	164	170	166	164	159	154	150	146	142	136	128	119	117	99	101	47	31	16	7	4	2
3.5U	180	179	181	182	178	174	169	166	163	161	156	150	144	133	127	167	58	34	19	10	6	3
3U	187	188	190	195	199	196	193	190	188	187	189	194	196	183	195	238	69	43	26	15	9	4
2.5U	199	201	205	219	233	231	230	229	231	238	242	241	265	324	353	353	90	51	29	17	11	7
2U	224	238	239	247	249	268	276	283	284	271	305	429	523	531	535	512	107	55	30	17	11	8
1.5U	292	308	315	320	314	322	335	354	407	535	641	836	864	808	807	562	119	57	29	15	11	8
1U	389	409	426	466	518	604	852	1510	1165	1292	1534	1429	1223	1111	1077	774	151	65	51	13	10	8
0.5U	721	1254	1148	1559	1848	2184	2583	2840	2740	2551	2285	1937	1588	1478	1335	712	207	98	63	13	8	6
0	3232	4595	5668	6698	7080	6947	6584	6103	5438	4452	3357	2464	1960	1674	1511	1001	308	149	61	11	4	3
0.5D	10956	13584	14479	14546	13806	11913	10445	8393	6643	5287	3677	2749	2221	1890	1688	1201	416	176	69	12	3	3
1D	17797	17932	17137	15870	14243	12331	10389	8712	7261	6031	4226	3039	2388	2033	1839	1372	575	219	75	14	3	8
1.5D	11740	12458	11904	11711	11808	10867	9626	8337	7163	6166	4543	3291	2579	2211	1990	1462	772	283	89	15	3	8
2D	7345	7949	7939	7510	7614	7729	7267	6645	5976	5355	4305	3367	2719	2350	2155	1557	961	357	110	19	6	3
2.5D	5240	5535	5754	5841	5797	5637	5393	5054	4669	4342	3741	3151	2696	2403	2242	1653	1093	446	140	54	8	5
3D	4152	4286	4430	4523	4503	4415	4259	4082	3863	3648	3224	2851	2557	2331	2224	1710	1171	546	175	57	9	5
3.5D	3346	3409	3471	3516	3519	3485	3404	3296	3162	3037	2745	2498	2315	2156	2091	1664	1206	614	220	58	11	5
4D	2731	2773	2812	2844	2846	2815	2751	2682	2596	2509	2317	2161	2044	1932	1892	1537	1184	667	262	63	32	6
4.5D	2257	2280	2300	2318	2309	2276	2227	2182	2125	2078	1945	1851	1785	1697	1673	1374	1100	675	292	65	31	6
5D	1879	1891	1910	1922	1911	1874	1841	1804	1761	1731	1631	1566	1531	1465	1446	1191	997	665	313	66	34	19

Table 8
Luminous intensities (cd) for the sales-weighted sample representing the low-beam headlamps on current vehicles in the U.S. that use the HB4 (9006) light source. The entry in each cell is the median (50th percentile). (Test voltage 12.8 V.)

	45L	40L	35L	30L	25L	20L	15L	10L	9L	8L	7L	6L	5L	4.5L	4L	3.5L	3L	2.5L	2L	1.5L	1L	0.5L	0
7U	38	43	42	35	34	33	39	54	52	54	59	60	64	66	66	67	68	68	69	70	72	77	96
6.5U	39	44	43	35	34	34	44	57	60	61	63	63	65	68	70	70	72	73	75	77	78	83	102
6U	41	46	45	35	36	37	46	60	61	63	66	66	69	70	72	74	78	79	81	82	86	90	111
5.5U	57	33	43	39	36	40	50	65	67	70	72	73	76	77	80	82	84	87	90	94	98	100	122
5U	58	36	47	39	37	42	54	68	73	76	79	80	84	86	87	89	93	97	99	103	109	116	120
4.5U	73	35	42	41	36	43	60	75	77	80	83	87	93	95	96	98	101	104	107	111	118	130	136
4U	74	32	42	40	37	45	69	84	88	90	93	95	99	101	105	108	111	114	117	121	129	140	156
3.5U	61	40	37	41	37	51	75	92	95	98	101	105	110	114	118	122	126	130	134	138	143	155	172
3U	52	40	42	38	39	55	81	99	106	109	116	121	128	132	135	140	144	148	153	157	163	170	180
2.5U	47	41	37	36	39	60	90	116	120	124	131	136	142	145	152	158	163	167	173	179	183	191	199
2U	48	49	37	36	40	64	94	136	144	146	155	160	166	175	183	191	195	200	206	211	221	226	237
1.5U	44	60	34	35	42	67	109	149	160	169	178	188	199	210	223	231	236	240	243	250	260	271	282
1U	42	57	36	33	47	78	124	185	192	200	208	226	250	273	284	295	307	319	342	346	359	370	393
0.5U	42	58	35	33	55	88	153	244	271	317	327	329	342	358	387	415	435	456	489	546	579	637	726
0	43	37	26	35	64	121	238	410	476	531	590	684	702	712	727	744	768	795	847	941	1130	1509	2361
0.5D	40	45	22	27	52	184	416	802	943	1064	1222	1521	1555	1574	1596	1635	1687	1764	1899	2110	2786	4092	7300
1D	35	51	30	26	62	311	744	1554	1763	1943	2165	2747	2869	2934	3009	3103	3254	3429	3684	4142	4910	6931	10969
1.5D	35	47	30	28	88	502	1308	2349	2463	2668	3372	3502	3691	3804	3938	4103	4338	4624	5040	5971	7573	9574	13996
2D	41	41	25	39	126	544	1973	2728	2847	3103	3667	3820	4035	4176	4323	4490	4824	5456	6286	7235	8200	11117	13804
2.5D	47	44	26	35	169	836	2296	2911	3006	3193	3464	3790	4008	4137	4366	4723	4896	5617	6474	7551	8545	8993	9335
3D	61	63	45	49	196	1169	2436	2820	3014	3231	3357	3581	4084	4313	4600	4900	5194	5778	6478	6892	7074	7197	7373
3.5D	68	62	41	52	200	1274	2092	2547	2677	2841	3023	3182	3344	3433	3575	3808	4182	4624	4863	5381	5474	5578	5605
4D	70	58	41	59	247	1096	1868	2251	2365	2454	2530	2621	2755	2836	2944	3099	3481	3625	3809	4374	4426	4156	4063
4.5D	73	49	40	57	280	961	1567	1892	1961	2020	2076	2151	2256	2308	2358	2528	2588	2711	3133	3084	3044	2983	2938
5D	74	47	40	60	270	861	1234	1469	1529	1588	1631	1683	1743	1772	1808	1954	2011	2103	2213	2213	2216	2207	2215

	0.5R	1R	1.5R	2R	2.5R	3R	3.5R	4R	4.5R	5R	6R	7R	8R	9R	10R	15R	20R	25R	30R	35R	40R	45R
7U	100	103	108	112	114	116	93	89	85	77	70	68	68	64	62	49	47	31	15	14	11	11
6.5U	106	109	115	118	121	123	103	98	92	89	82	76	73	69	67	51	48	25	16	15	11	11
6U	116	120	126	130	133	135	134	108	101	97	90	85	80	76	73	55	49	27	17	15	11	12
5.5U	127	135	141	146	148	149	149	146	115	110	100	94	89	85	80	57	50	28	17	16	11	12
5U	148	157	163	168	167	166	164	160	154	125	114	107	100	108	102	61	53	27	18	16	11	11
4.5U	139	176	185	189	190	191	188	180	174	166	128	118	111	120	113	66	54	29	19	17	11	11
4U	159	159	168	211	212	212	207	200	194	185	167	154	143	133	128	74	50	27	22	18	10	11
3.5U	176	180	189	232	235	237	237	231	224	214	192	175	163	153	130	82	50	30	21	20	12	11
3U	198	205	211	216	217	217	213	207	204	200	217	196	182	146	148	96	55	31	21	19	11	11
2.5U	212	226	238	239	239	236	233	229	226	220	208	193	177	163	161	115	60	33	22	18	12	10
2U	248	256	258	273	285	278	271	260	247	242	232	218	222	192	178	123	70	35	23	18	11	10
1.5U	301	316	325	336	343	345	347	339	308	292	292	277	280	247	213	139	88	41	23	19	10	10
1U	411	426	475	524	572	628	677	647	570	492	406	363	349	295	255	161	106	51	25	16	10	9
0.5U	877	1056	1238	1480	1533	1515	1549	1509	1393	1172	841	588	535	444	379	199	127	63	28	16	11	8
0	3300	3817	4365	4798	5286	5704	5624	5317	4471	3690	2208	1433	1099	932	755	311	170	83	25	17	11	10
0.5D	11084	14232	16061	16487	15463	15024	14385	12910	10784	8801	4397	2688	1986	1745	1271	558	229	102	29	10	10	10
1D	15605	19649	22727	24484	24770	23922	21777	19365	16190	12699	7470	3905	3108	2577	1900	892	346	163	26	10	10	10
1.5D	17404	20438	23109	24887	25015	24654	25198	23133	20434	13833	8284	5383	4417	3814	3093	1263	594	271	33	10	10	10
2D	14706	16278	17124	17263	17814	17881	17063	15708	14563	12911	9639	6879	5723	4556	3629	1729	1034	397	43	13	10	10
2.5D	9971	10470	10731	10775	10796	10863	10804	10601	10149	9411	7280	5973	5528	5280	4212	2544	1317	545	56	23	10	10
3D	7472	7473	7660	7681	7662	7502	7451	7343	7395	7111	6618	5579	5433	5353	4442	3386	1480	630	59	22	10	10
3.5D	5462	5446	5537	5831	6077	6039	5973	5809	5660	5535	5481	4713	4675	4733	4467	3632	1607	726	59	27	10	9
4D	3989	3982	3995	4085	4355	4612	4803	4643	4497	4358	4134	3899	3706	3674	3685	3341	1841	544	54	27	28	8
4.5D	2923	2923	2935	2992	3060	3173	3237	3366	3589	3387	3263	3130	3020	3049	2953	2534	2169	511	50	27	31	15
5D	2209	2204	2217	2256	2285	2293	2293	2314	2352	2426	2529	2350	2278	2320	2349	2092	1918	538	54	33	36	20

Table 9
Luminous intensities (cd) for the sales-weighted sample representing the low-beam headlamps on current vehicles in the U.S. that use the HB5 (9007) light source. The entry in each cell is the median (50th percentile). (Test voltage 12.8 V.)

	45L	40L	35L	30L	25L	20L	15L	10L	9L	8L	7L	6L	5L	4.5L	4L	3.5L	3L	2.5L	2L	1.5L	1L	0.5L	0
7U	21	21	15	22	32	35	37	45	49	52	54	58	59	61	62	64	67	70	72	75	78	82	87
6.5U	21	21	15	22	33	40	38	52	52	55	57	62	65	67	69	72	76	79	82	84	88	94	99
6U	21	23	16	23	34	42	41	53	59	61	62	67	71	73	77	80	83	84	89	92	98	104	110
5.5U	21	26	16	22	32	43	44	61	64	69	73	78	83	86	91	92	94	98	104	107	113	117	124
5U	20	27	18	22	35	42	47	66	68	76	86	91	95	98	99	101	103	108	112	117	124	128	134
4.5U	19	28	19	22	35	43	51	72	76	87	99	106	111	110	112	116	120	125	130	134	139	145	156
4U	17	29	20	22	41	45	54	77	82	100	110	119	123	123	125	129	134	140	144	150	158	165	176
3.5U	16	27	21	23	40	48	59	86	101	112	127	136	145	146	150	153	163	172	178	187	193	202	214
3U	15	31	22	23	43	56	67	94	112	125	136	139	150	154	161	172	179	194	208	222	234	247	250
2.5U	16	26	22	23	39	62	77	115	127	140	156	166	178	192	196	205	220	232	246	261	275	291	299
2U	16	23	21	22	44	68	90	127	137	152	169	190	224	232	239	254	274	280	295	320	348	370	387
1.5U	16	23	20	23	44	74	116	155	163	177	195	224	256	273	285	303	344	378	408	450	474	536	569
1U	15	22	20	25	45	80	137	197	208	224	248	291	353	386	384	443	492	583	607	691	756	837	945
0.5U	13	22	20	26	45	92	173	286	306	332	362	404	481	536	619	687	794	857	993	1119	1319	1698	2430
0	10	10	10	10	41	100	292	457	496	563	603	673	801	888	1036	1136	1305	1428	1675	1890	2424	3204	4790
0.5D	10	10	10	10	60	130	475	767	853	969	1132	1295	1563	1695	1837	2003	2516	2979	3255	3738	4574	7225	11397
1D	10	10	10	28	113	240	884	1532	1699	1980	2166	2485	3444	3899	4448	4868	5299	5868	6672	7611	9113	11643	17066
1.5D	10	10	10	36	187	479	1260	2318	2617	2973	3236	3618	4306	4993	5564	6643	8086	9572	11152	13111	15998	19447	22232
2D	10	11	11	44	352	650	1797	2776	3275	3488	3905	4361	5265	6060	7173	8237	9124	10273	11969	14470	17283	18833	21252
2.5D	10	11	11	60	322	879	2255	3159	3518	3820	4279	4810	5491	6161	7303	7656	8384	9576	11339	12645	14004	14597	15301
3D	10	10	11	37	362	989	2311	3290	3469	3777	4109	4536	5306	5614	6005	6378	6938	7555	8603	9590	10401	10996	11331
3.5D	10	23	24	54	307	1051	2129	2739	2871	2988	3260	3642	4170	4346	4417	4772	5234	5808	6371	6831	7114	7339	7501
4D	20	25	23	53	272	981	1721	2268	2380	2395	2561	2926	2990	3141	3289	3522	3907	4287	4394	4583	4759	4769	4721
4.5D	17	22	23	50	222	857	1419	1808	1878	1901	2117	2259	2312	2370	2463	2558	2644	2713	2812	2861	2956	3122	3034
5D	15	20	24	43	227	792	1272	1510	1562	1506	1524	1644	1802	1826	1856	1889	1962	2014	2089	2161	2202	2246	2317

	0.5R	1R	1.5R	2R	2.5R	3R	3.5R	4R	4.5R	5R	6R	7R	8R	9R	10R	15R	20R	25R	30R	35R	40R	45R
7U	89	91	94	96	103	99	95	91	85	80	72	66	60	56	54	47	39	27	19	13	11	9
6.5U	105	108	110	110	109	107	103	98	92	87	79	70	65	61	57	50	41	29	18	14	14	10
6U	115	119	123	124	123	121	118	113	107	102	92	82	75	72	67	54	42	29	21	14	14	10
5.5U	130	135	138	139	139	136	132	124	119	113	102	94	90	85	81	58	45	32	23	15	14	10
5U	144	151	158	161	159	156	153	148	141	135	124	116	108	108	98	70	48	33	23	17	12	10
4.5U	165	178	182	184	183	179	176	170	166	159	147	136	127	123	119	79	55	36	21	16	11	10
4U	191	202	209	211	212	211	206	201	193	184	167	158	144	138	131	95	62	37	22	16	11	10
3.5U	226	237	244	248	246	240	231	221	212	203	186	177	166	160	152	103	67	40	22	16	11	11
3U	264	275	288	293	292	286	276	261	248	240	219	204	192	180	175	124	79	42	23	16	11	11
2.5U	317	328	335	339	335	325	308	293	280	269	244	232	222	210	205	143	91	46	24	17	12	11
2U	410	428	454	452	454	450	440	440	413	383	322	300	282	268	263	194	116	49	26	18	12	10
1.5U	615	638	644	671	700	708	706	675	620	556	450	422	408	371	352	259	146	56	28	17	12	8
1U	1084	1224	1450	1567	1556	1542	1448	1323	1207	1105	919	713	600	564	569	417	195	81	30	18	13	10
0.5U	3016	3166	2983	2935	3062	2896	2654	2439	2172	2021	1959	1621	1116	973	986	697	276	110	31	18	12	9
0	6423	7001	7213	7929	7456	7080	5943	5137	4611	4046	2997	2872	2059	1709	1705	1101	465	138	29	10	10	10
0.5D	14288	14497	14849	16188	16284	14789	12431	10444	9085	7745	4931	3971	3004	2881	2819	1992	843	208	27	10	9	10
1D	18582	20409	21398	20842	21293	19607	15965	13050	10712	8693	5886	5159	4573	4240	3798	1967	1243	284	42	12	10	10
1.5D	24514	26052	27021	26035	25200	24080	21940	19399	16248	13801	10757	7660	5340	4845	4344	2464	1661	321	47	12	10	10
2D	22000	22702	23161	23452	23399	21836	20806	19573	18214	16722	13488	9810	6549	4846	4297	2730	1427	291	54	13	10	10
2.5D	16166	16104	15971	15867	16064	15720	15074	14316	13349	12105	9811	7666	6216	5219	4534	2804	1207	407	67	13	10	10
3D	11574	11519	11426	11115	10754	10309	9627	9383	8677	8030	7091	5769	4776	4175	3598	2476	1608	563	79	20	10	10
3.5D	7628	7416	7204	6843	6452	6072	5673	5518	5361	4962	4499	4095	3633	3238	3105	2298	1443	404	86	18	10	10
4D	4741	4619	4535	4326	4133	3946	3791	3668	3434	3334	3007	2864	2477	2282	2176	1851	1147	422	67	26	13	10
4.5D	3189	3119	3122	3104	3065	2994	2866	2835	2636	2459	2260	2003	1829	1685	1616	1480	883	320	58	26	14	9
5D	2314	2297	2292	2258	2213	2175	2117	2068	2019	1947	1736	1586	1448	1350	1251	1179	721	231	51	28	15	9

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