

# OFFICE MEMORANDUM



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To: H. H. Cooper  
Engineer of Traffic and Safety

From: Max N. Clyde

**Subject:** Experimental Vehicle Traffic Control Signals: Final Report.  
Research Project 71 TI-39. Research Report No. R-797.

In reference to your letter of May 5, 1971 concerning experimental signals, the Eagle and 3M traffic control signals have been tested. A progress report (September 17, 1971) presented test results; except for the lens face luminance test results on a Lexan plastic Eagle signal with Lexan lenses. This report includes results of luminance measurements on the plastic lenses along with photometric and color test results on the Eagle and 3M traffic control signals listed in Table 1. The table shows the laboratory sample number, reference to a figure showing each signal section, the manufacturers name, signal size, signal description, and lens colors supplied for testing.

TABLE 1  
EXPERIMENTAL SIGNALS AND ACCESSORIES

Laboratory Sample No.	Figure No.	Accessories	Mfr.	Nominal Size, in.	Lens Color
71 TS 32	1		Eagle	12	yellow
71 TS 30	2	Adapter including louvers and rectangular lens	Eagle	12	yellow
71 TS 35	3	3 optical units (Model M-123)	3M	8	red, yellow, green
71 TS 34	4		Eagle	8	red, yellow, green
71 TS 36	5	Louvered adapter (Strateray Model A)	Eagle	8	no lens
71 TS 29	6	Lens system adapter	3M	8	green
71 TS 31	7	Adapter, Model SA-080	3M	8	no lens

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The tests were conducted in accordance with the methods described in the ITE "Standard for Adjustable Face Vehicle Traffic Control Signal Heads," dated May, 1966.

Lens colors were tested by comparing lens chromaticity with National Bureau of Standards calibrated limit glasses. All lenses furnished with the signals as shown in Table 1 conformed with chromaticity requirements except the green lens of the 12-in. 3M signal (71 TS 35) which was more yellow than the yellow limit. Luminous transmittance values were not determined.

Light distribution and candlepower intensity were determined on each of the signal sections listed in Table 1. Charts 1 through 21 show the distributions of light obtained when the signal sections are illuminated with a selected traffic signal lamp corrected to the ITE standard lumen output, or with a special lamp corrected to the lamp manufacturer's lumen ratings. The special lamps were provided with the signal sections and are noted on the charts.

Charts 1, 2, and 3 show the requirements calculated for each color of 12-in. lens and Charts 4, 5, and 6 show the requirements calculated for each color of 8-in. lens as established by the ITE standard. Chart 7 shows the intensity distribution of an Eagle 12-in. traffic signal section. Charts 8 through 11 show the effects of adding a louvered adapter (Fig. 2). Charts 12, 13, and 14 show the intensity distribution of each color indication from a 3M Model M-123, 12-in. traffic signal. Chart 15 shows the effects of masking the 3M signal at the upper right quadrant. Chart 16 shows the intensity distribution of an Eagle 8-in. traffic signal section and Chart 17 shows the effects of adding the Eagle Strateray louvered adapter (Fig. 5) to the signal. Charts 18 through 21 show the effects of adding the 3M adapter (Figs. 6 and 7) to the 8-in. Eagle signal. The lines of the adapter lens (Fig. 7) were oriented vertically and directed the signal beam to the left (Chart 20). By rotating the adapter lens  $180^\circ$  the beam was directed to the right (Chart 21).

Distributions shown on the charts can be summarized as follows:

- 1) None of the special signals and none of the signals fitted with adapters conform to the ITE standard.
- 2) The effects of adding the louvered Eagle adapter to an Eagle signal are shown in Figure 8 by plotting intensity at all test points on the plane  $2.5^\circ$  below the horizontal.
- 3) The 3M Model M-123 signal shows a very small cone (Charts 12, 13, 14) at the center of a traffic signal distribution. Masking the upper right quadrant of the signal shows an effect in the lower right quadrant because the lens inverts the image.
- 4) The Eagle Strateray louvered adapter mounted on an 8-in. signal restricted the distribution and intensity (Chart 17) approximately the same as the louvered adapter with every third louver in place on a 12-in. signal (Chart 8).

Luminance measurements of the Lexan plastic and glass lens faces were made on the Lexan plastic 8-in. Eagle signal after the September report was released. These measurements were compared with similar measurements of glass lenses in the same signal section. The luminance measurements were expected to show uniformity of face brightness and the comparison was to indicate whether plastic or glass lenses had the more uniform appearance. Figures 9 and 10 show the luminance values obtained in the small measuring area on a yellow plastic and glass lens, respectively. The brightness meter was located  $7-1/2^\circ$  below the horizontal with respect to the signal. Results of the measurements indicated variations in brightness over the face of the lenses were approximately equal.

No further tests are planned on any of the signals or signal accessories received for this project.

TESTING AND RESEARCH DIVISION

*Max*

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Engineer of Testing and Research

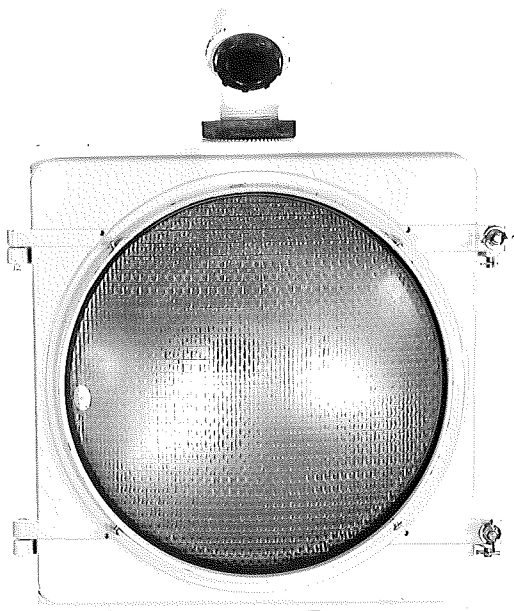


Figure 1. Twelve-inch Eagle Signal (71 TS 32).

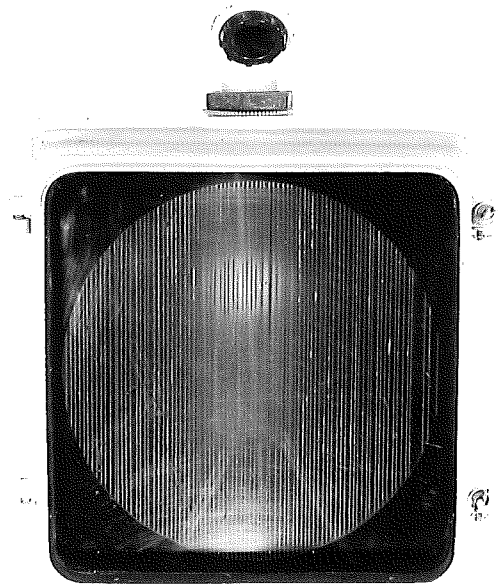
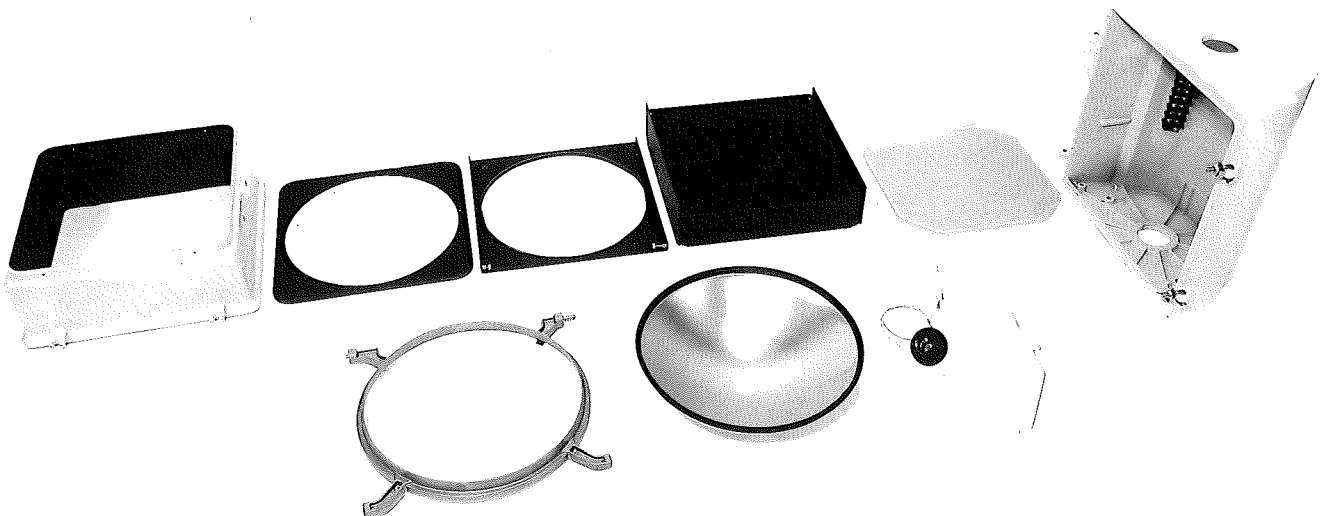


Figure 2. Louvered Adapter (71 TS 30) mounted on 71 TS 32 Eagle Signal.



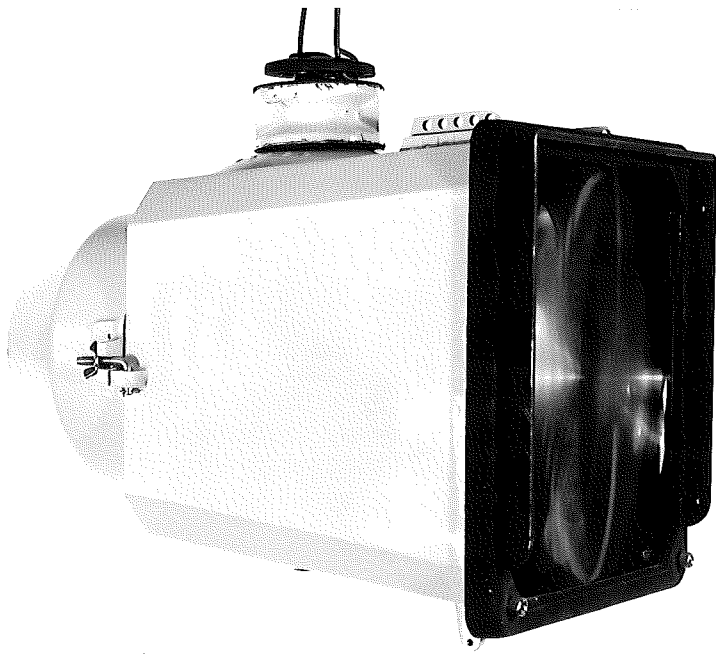


Figure 3. 3M Model M-123 Traffic Signal (71 TS 35).





Figure 6. 3M Lens System Adapter (71 TS 29) mounted on 71 TS 34 Eagle Signal.

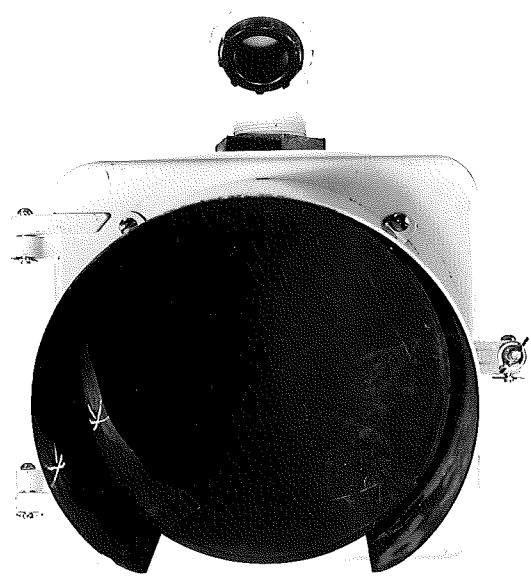
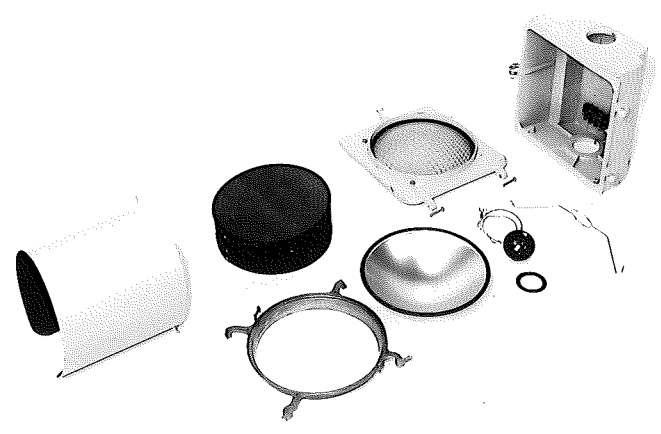


Figure 7. 3M Model SA-080 Adapter (71 TS 31) mounted on 71 TS 34 Eagle Signal.



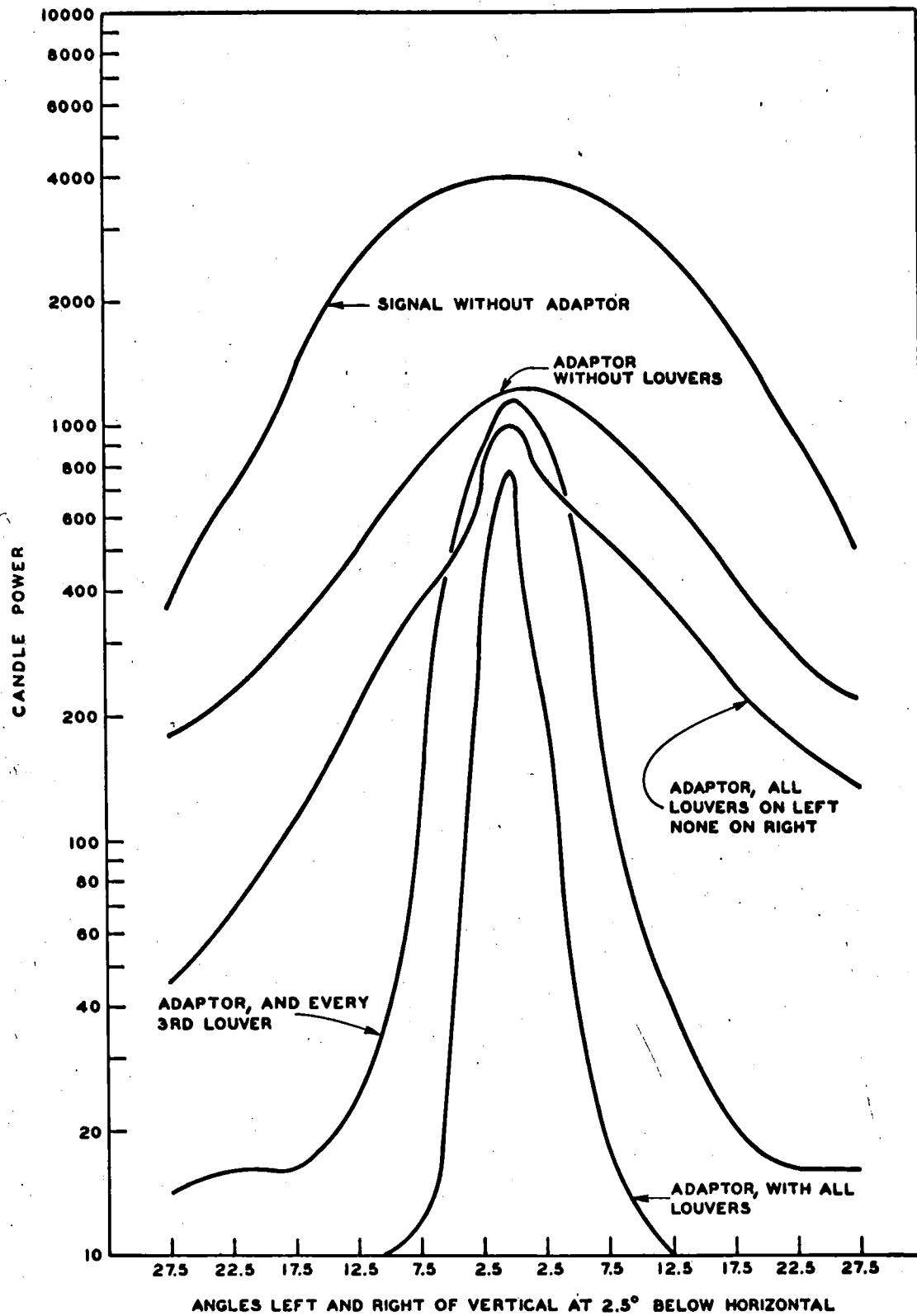


Figure 8. Intensity distribution for Eagle 12-in. Signal with and without Louvered Adaptor.



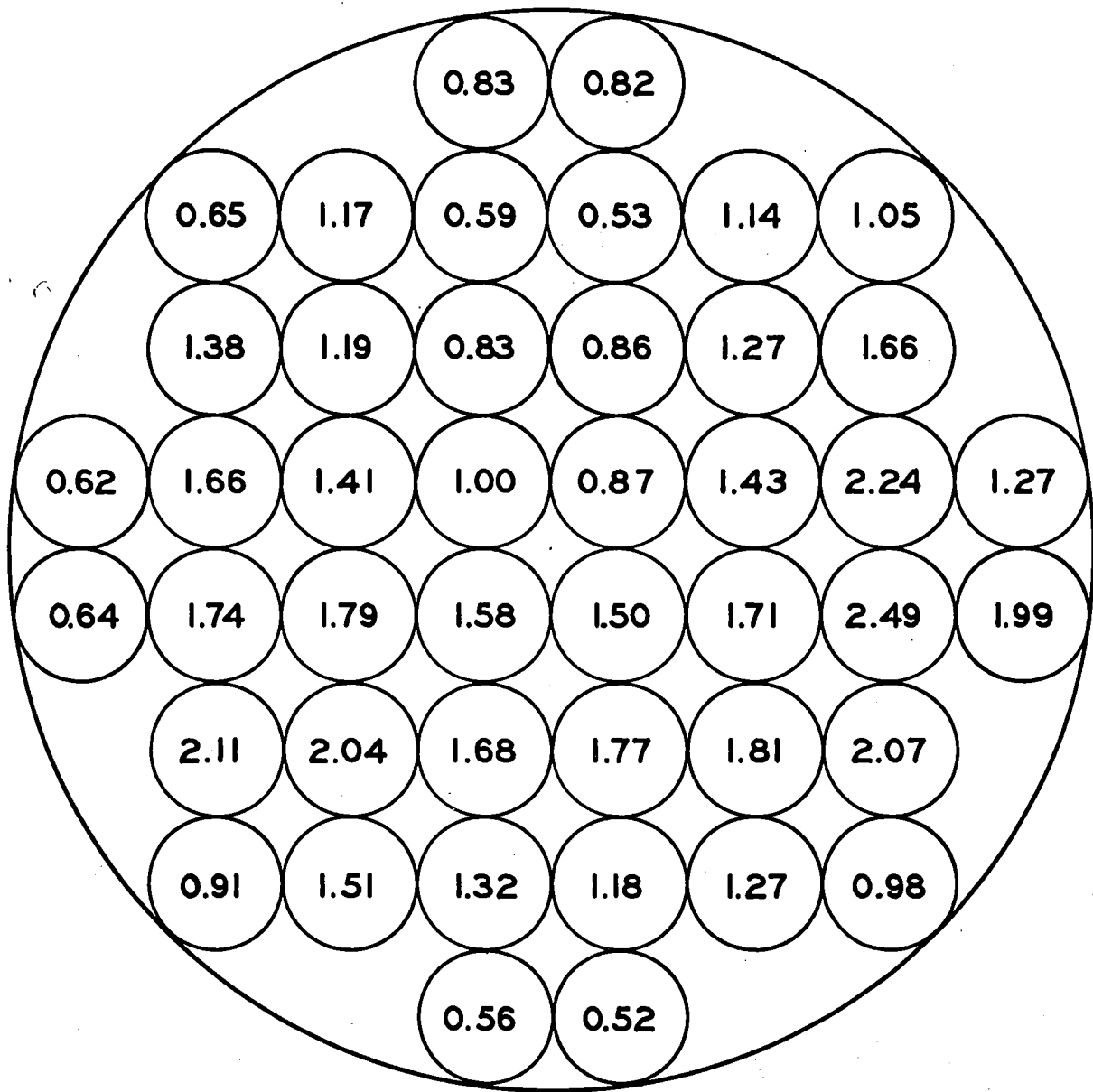


Figure 9. Luminance values for 8-in. yellow plastic lens.

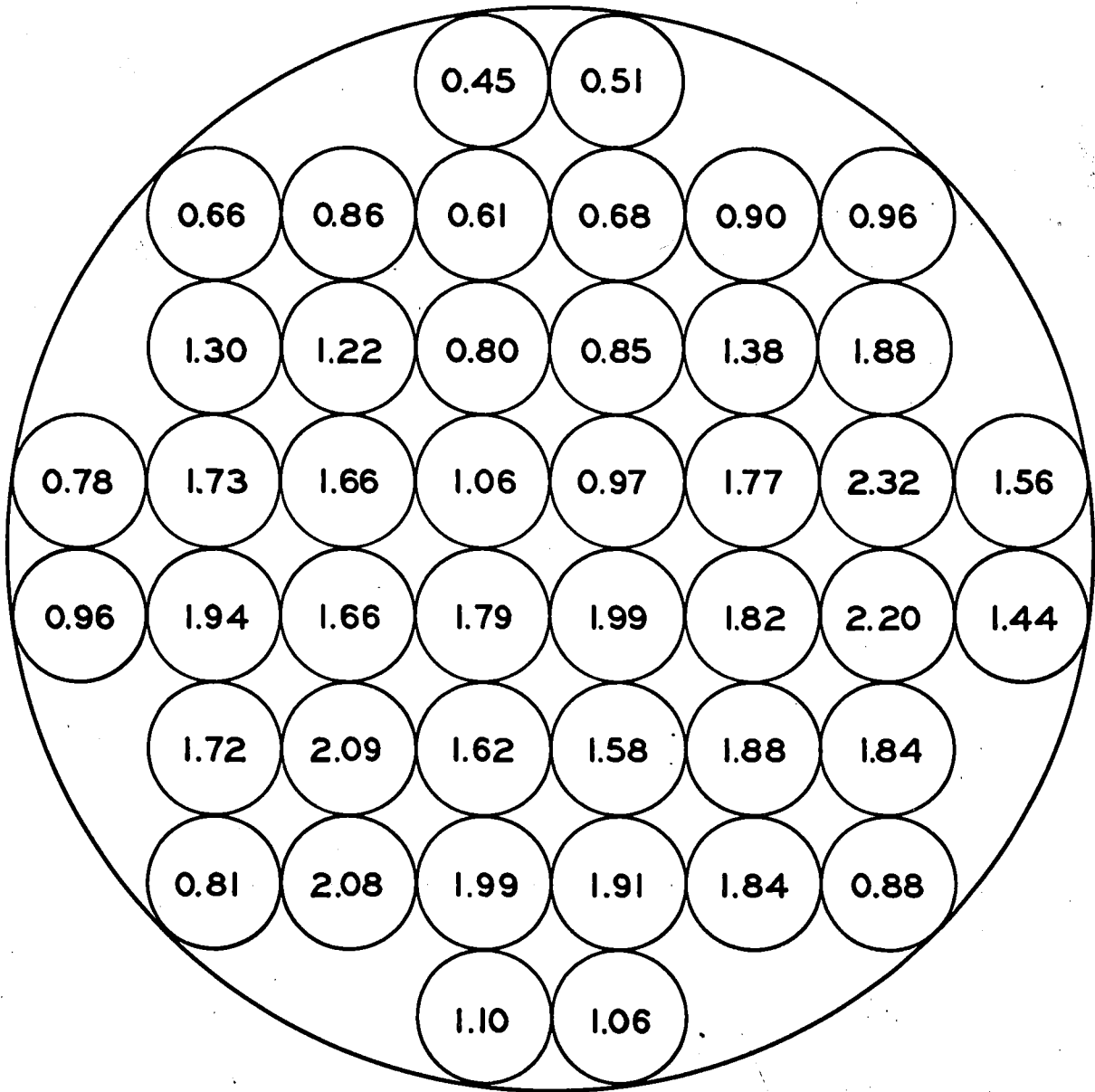


Figure 10. Luminance values for 8-in. yellow glass lens.

**CANDLEPOWER CHART 1**  
ITE Standard for 12-in. wide angle lens  
(Values corrected to minimum for red lens)

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							0.0	RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	2.5°		7.5°	12.5°	17.5°	22.5°	27.5°		
0.0	--	--	--	--	--	--	--	--	--	--	--	--	0.0		
-2.5°	--	--	90	166	295	399	--	399	295	166	90	--	-2.5		
-7.5°	19	45	104	171	238	266	--	266	238	171	104	45	19		
-12.5°	19	26	40	52	57	59	--	59	57	52	40	26	19		
-17.5°	19	24	26	26	26	26	--	26	26	26	26	24	19		

**CANDLEPOWER CHART 2**  
ITE Standard for 12-in. wide angle lens  
(Values corrected to minimum for yellow lens)

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							0.0	RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	2.5°		7.5°	12.5°	17.5°	22.5°	27.5°		
0.0	--	--	--	--	--	--	--	--	--	--	--	--	0.0		
-2.5°	--	--	418	770	1360	1850	--	1850	1360	770	418	--	-2.5		
-7.5°	88	209	484	792	1100	1230	--	1230	1100	792	484	209	88		
-12.5°	88	121	188	242	264	275	--	275	264	242	188	121	88		
-17.5°	88	110	121	121	121	121	--	121	121	121	121	110	88		

**CANDLEPOWER CHART 3**  
ITE Standard for 12-in. wide angle lens  
(Values corrected to minimum for green lens)

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							0.0	RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	2.5°		7.5°	12.5°	17.5°	22.5°	27.5°		
0.0	--	--	--	--	--	--	--	--	--	--	--	--	0.0		
-2.5°	--	--	190	350	620	840	--	840	620	350	190	--	-2.5		
-7.5°	40	95	220	360	500	560	--	560	500	360	220	95	40		
-12.5°	40	55	85	110	120	125	--	125	120	110	85	55	40		
-17.5°	40	50	55	55	55	55	--	55	55	55	55	50	40		

Note: Intensity values based on 150 watt traffic signal lamp with 1950 lumen output.

**CANDLEPOWER CHART 4**  
ITE Standard for 8-in. lens  
(Values corrected to minimum for red lens)

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT						0.0	RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°		2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	
0.0	--	--	--	--	--	--	--	--	--	--	--	--	0.0	
-2.5°	--	--	28	66	114	157	--	157	114	66	28	--	-2.5	
-7.5°	12	21	48	76	104	119	--	119	104	76	48	21	12	-7.5
-12.5°	10	14	24	33	38	43	--	43	38	33	24	14	10	-12.5
-17.5°	6	6	10	12	16	19	--	19	16	12	10	6	6	-17.5

**CANDLEPOWER CHART 5**  
ITE Standard for 8-in. lens  
(Values corrected to minimum for yellow lens)

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT						0.0	RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°		2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	
0.0	--	--	--	--	--	--	--	--	--	--	--	--	0.0	
-2.5°	--	--	132	308	528	726	--	726	528	308	132	--	-2.5	
-7.5°	55	99	220	352	484	550	--	550	484	352	220	99	55	-7.5
-12.5°	44	66	110	154	194	198	--	198	194	154	110	66	44	-12.5
-17.5°	22	33	44	55	77	88	--	88	77	55	44	33	22	-17.5

**CANDLEPOWER CHART 6**  
ITE Standard for 8-in. lens  
(Values corrected to minimum for green lens)

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT						0.0	RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°		2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	
0.0	--	--	--	--	--	--	--	--	--	--	--	--	0.0	
-2.5°	--	--	60	140	240	330	--	330	240	140	60	--	-2.5	
-7.5°	25	45	100	160	220	250	--	250	220	160	100	45	25	-7.5
-12.5°	20	30	50	70	80	90	--	90	80	70	50	30	20	-12.5
-17.5°	10	15	20	25	35	40	--	40	35	25	20	15	10	-17.5

Note: Intensity values based on 80 watt traffic signal lamp with 665 lumen output

**CANDLEPOWER CHART 7**  
Eagle Signal (71-TS 32) with 12-in. yellow lens

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	0.0	2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	
0.0	341	602	1100	2100	2900	3370	3420	3460	3210	2500	1580	874	448	0.0
-2.5°	362	682	1270	2400	3320	3750	3840	3870	3470	2620	1640	943	480	-2.5
-7.5°	312	541	914	1500	1950	2120	2100	2070	1940	1500	956	589	357	-7.5
-12.5°	207	261	342	436	541	578	576	568	517	424	322	241	204	-12.5
-17.5°	181	198	216	239	271	277	278	278	263	246	221	202	184	-17.5

Note: Intensity values based on 150 watt traffic signal lamp with 1950 lumen output.

**CANDLEPOWER CHART 8**  
Eagle Signal (71-TS 32) with 71-TS 30 louvered adapter  
with yellow lens, minus all louvers

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	0.0	2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	
0.0	184	228	315	479	731	1030	1120	1120	908	628	407	284	217	0.0
-2.5°	184	228	322	497	761	1100	1190	1200	971	665	427	291	217	-2.5
-7.5°	179	223	308	462	707	987	1080	1100	932	645	422	284	214	-7.5
-12.5°	174	212	277	381	547	708	787	799	710	521	363	263	204	-12.5
-17.5°	165	189	232	296	381	459	487	498	464	380	291	225	181	-17.5

**CANDLEPOWER CHART 9**  
Eagle Signal (71-TS 32) with 71-TS 30 louvered adapter  
with yellow lens and every third louver

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	0.0	2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	
0.0	16	16	16	24	112	826	1120	938	142	39	20	14	16	0.0
-2.5°	14	16	16	24	116	853	1150	957	144	41	20	16	16	-2.5
-7.5°	10	10	10	22	98	751	1000	814	128	35	16	16	16	-7.5
-12.5°	8	8	8	21	83	604	846	532	94	30	17	10	8	-12.5
-17.5°	2	2	2	5	47	308	388	313	57	13	4	2	2	-17.5

**CANDLEPOWER CHART 10**  
Eagle Signal (71-TS 32) with 71-TS 30 louvered adapter  
with yellow lens, all louvers installed

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	0.0	2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	
0.0	7	7	7	7	14	294	724	211	16	9	7	7	7	0.0
-2.5°	7	7	7	7	12	313	766	219	18	10	8	8	7	-2.5
-7.5°	7	8	8	7	11	317	682	189	18	10	8	7	7	-7.5
-12.5°	7	8	7	8	10	238	486	120	19	10	8	8	8	-12.5
-17.5°	4	4	4	4	7	159	299	73	9	5	4	4	4	-17.5

Note: Intensity values based on 150 watt traffic signal with 1950 lumen output.

**CANDLEPOWER CHART 11**  
Eagle Signal (71-TS 32) with 71-TS 30 louvered adapter  
with yellow lens, all louvers on left none on right

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	0.0	2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	
0.0	45	67	107	195	345	685	920	672	487	337	233	172	132	0.0
-2.5°	45	65	110	202	359	745	986	716	525	354	237	172	132	-2.5
-7.5°	44	65	106	190	332	675	878	654	496	347	232	171	132	-7.5
-12.5°	43	67	89	148	243	467	616	463	372	280	205	154	122	-12.5
-17.5°	36	49	71	108	161	304	380	281	241	202	164	135	114	-17.5

Note: Intensity values based on 150 watt traffic signal lamp with 1950 lumen output.

**CANDLEPOWER CHART 12**  
 3M Model M 123 traffic signal (71-TS 35)  
 with red lens

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	0.0	2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	0.0
0.0	4	4	4	108	195	606	639	574	221	70	6	6	6	0.0
-2.5°	4	4	4	108	182	521	575	560	197	66	66	6	6	-2.5
-7.5°	3	3	3	7	102	235	282	239	103	78	4	4	3	-7.5
-12.5°	1	1	1	1	18	81	78	81	69	1	1	1	1	-12.5
-17.5°	1	1	1	1	1	1	1	1	1	1	1	1	1	-17.5

**CANDLEPOWER CHART 13**  
 3M Model M-123 traffic signal (71-TS 35)  
 with yellow lens

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	0.0	2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	0.0
0.0	23	23	23	492	877	2180	2590	2340	933	302	32	22	23	0.0
-2.5°	23	23	23	473	775	2290	2400	2370	942	316	32	22	23	-2.5
-7.5°	12	12	12	16	464	1080	1180	1080	464	323	16	16	16	-7.5
-12.5°	4	4	5	9	12	366	348	393	16	10	6	4	1	-12.5
-17.5°	--	--	--	3	7	14	16	16	12	7	2	--	--	-17.5

**CANDLEPOWER CHART 14**  
 3M Model M-123 traffic signal (71-TS 35)  
 with green lens

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	0.0	2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	0.0
0.0	5	5	5	185	326	840	1080	940	340	112	8	7	7	0.0
-2.5°	5	5	5	181	312	879	950	925	353	110	8	7	7	-2.5
-7.5°	4	4	4	14	167	362	397	359	160	101	5	4	7	-7.5
-12.5°	1	1	1	1	21	134	130	135	81	3	1	1	1	-12.5
-17.5°	1	1	1	1	1	3	3	4	3	1	1	1	1	-17.5

**CANDLEPOWER CHART 15**  
 3M Model M-123 traffic signal (71-TS 35)  
 with yellow lens, upper right quadrant masked

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	0.0	2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	0.0
0.0	19	19	19	469	826	2120	2510	1940	708	190	32	28	23	0.0
-2.5°	23	23	23	460	817	2250	2180	37	32	28	23	23	19	-2.5
-7.5°	7	8	8	8	428	723	852	35	20	10	8	8	8	-7.5
-12.5°	4	4	4	6	9	348	232	22	13	10	7	4	4	-12.5
-17.5°	--	--	--	1	5	9	8	6	3	1	--	--	--	-17.5

Note: Intensity values based on GE PAR 46 sealed beam lamp with 1600 lumen output.

**CANDLEPOWER CHART 16**  
Eagle Signal (71 - TS 34) with 8-in. yellow lens

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT						0.0	RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°		2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	
0.0	--	--	--	--	--	--	--	--	--	--	--	--	0.0	
-2.5°	110	147	229	410	745	996	--	960	686	376	218	149	112	-2.5
-7.5°	149	216	336	560	819	888	--	856	723	488	302	204	143	-7.5
-12.5°	129	189	268	382	493	499	--	465	401	307	220	165	120	-12.5
-17.5°	84	105	132	165	192	201	--	196	172	142	112	89	74	-17.5

Note: Intensity values based on 60 watt traffic signal lamp with 665 lumen output.

**CANDLEPOWER CHART 17**  
Eagle Signal (71 - TS 34) with 8-in. yellow lens  
and with 71TS-36 Strateray louvered adapter

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT						0.0	RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°		2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	
0.0	9	9	10	27	213	661	765	509	114	19	16	12	11	0.0
-2.5°	19	19	19	34	431	1160	1090	750	168	24	17	19	19	-2.5
-7.5°	12	12	13	39	430	902	883	655	180	24	17	16	15	-7.5
-12.5°	6	7	9	27	233	463	460	342	104	18	12	10	10	-12.5
-17.5°	4	4	5	13	89	174	182	140	46	11	6	5	5	-17.5

Note: Intensity values based on 60 watt traffic signal lamp with 665 lumen output.

**CANDLEPOWER CHART 18**  
Eagle Signal (71-TS 34) with 71-TS 29 3M adapter  
with 8-in. green lens

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT						0.0	RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°		2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	
0.0	--	--	--	--	--	--	--	--	--	--	--	--	--	0.0
-2.5°	3	3	27	49	67	103	97	65	54	30	5	3	3	-2.5
-7.5°	2	2	21	38	42	62	67	55	46	27	4	3	3	-7.5
-12.5°	--	1	13	26	32	35	40	40	32	17	1	1	1	-12.5
-17.5°	--	--	2	13	21	26	28	25	18	2	--	--	--	-17.5

Note: Intensity values based on GE (69A 19 TS/1F 8000 hr) 69 watt frosted lamp with 675 lumen output.

**CANDLEPOWER CHART 19**  
Eagle Signal (71-TS 34) with 71-TS 29 3M adapter  
with 8-in. green lens

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT						0.0	RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°		2.5°	7.5°	12.5°	17.5°	22.5°	27.5°	
0.0	2	2	63	103	138	194	229	213	142	104	51	4	3	0.0
-2.5°	2	2	64	102	126	190	205	207	134	102	60	3	2	-2.5
-7.5°	2	2	58	94	111	136	146	139	114	92	54	4	3	-7.5
-12.5°	1	1	40	61	101	107	109	105	94	76	22	1	1	-12.5
-17.5°	1	1	1	49	74	85	85	83	73	47	1	1	1	-17.5

Note: Intensity values based on Luxor krypton 100 watt opalised lamp with 1460 lumen output.



**CANDLEPOWER CHART 20**  
 Eagle Signal (71 - TS 34) with 8-in. yellow lens  
 and with 71 - TS 31 3M adapter at left beam orientation

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							0.0	RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	2.5°		7.5°	12.5°	17.5°	22.5°	27.5°		
0.0	9	23	56	169	395	387	244	116	18	9	7	5	4	0.0	
-2.5°	11	28	80	273	606	627	335	163	21	9	9	9	9	-2.5	
-7.5°	11	28	101	339	598	451	290	158	21	9	9	9	9	-7.5	
-12.5°	8	20	79	217	349	247	161	94	21	15	13	12	12	-12.5	
-17.5°	3	8	32	88	134	99	86	37	8	3	3	2	2	-17.5	

Note: Intensity values based on 60 watt traffic signal lamp with 665 lumen output.

**CANDLEPOWER CHART 21**  
 Eagle Signal (71-TS 34) with yellow lens  
 and with 71-TS 31 3M adapter at right beam orientation

Angles left and right of vertical

ANGLES BELOW HORIZONTAL	LEFT							0.0	RIGHT						
	27.5°	22.5°	17.5°	12.5°	7.5°	2.5°	2.5°		7.5°	12.5°	17.5°	22.5°	27.5°		
0.0	4	5	5	5	9	85	172	267	300	147	57	30	13	0.0	
-2.5°	4	4	5	5	12	130	281	410	461	222	86	40	16	-2.5	
-7.5°	5	4	4	5	18	142	250	374	488	280	110	43	18	-7.5	
-12.5°	4	4	5	5	11	81	142	200	264	178	77	31	12	-12.5	
-17.5°	1	1	1	1	4	28	64	85	117	81	34	13	4	-17.5	

Note: Intensity values based on 60 watt traffic signal lamp with 665 lumen output.