149

HIGHWAY RESEARCH
CIRCULAR

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Maintenance, General
Highway Safety
Traffic Control and Operations

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FIXED HIGHWAY LIGHTING: DESIGN AND OPERATION

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I N D E X

Fixed Highway Lighting

FOREWORD

One of the primary functions of the Highway Research Board's Visibility Committee is the accumulation and dissemination of up-to-date knowledge on all aspects of visibility. In carrying out this function it is important to maintain an awareness of current operational policies and practices related to visibility, since these practices not only reflect current thinking but also influence the direction of future activities.

One area within visibility that currently is receiving increasing (and well-deserved) attention is Fixed Highway Lighting. In particular, there has been growing concern about the lack of international standards and, indeed, the lack of uniformity in practice among the United States, themselves. To document the degree of this non-uniformity in the U. S., and as a first step toward addressing the broader concern over international standards, the Visibility Committee decided in 1972 to survey the States with regard to their current and proposed fixed lighting policies and practices. An Ad Hoc Committee was appointed to prepare and administer a questionnaire. The Committee was chaired by Ralph R. Lau, and included Neilon J. Rowan, Richard N. Schwab and Richard E. Stark.

The questionnaire was distributed to state highway representatives of all 50 states, Puerto Rico and the District of Columbia in late December, 1972. By early Spring, 1973, 49 questionnaires had been returned. This publication is devoted to a non-critical presentation of the information provided by these 49 respondents. The first section summarizes the data for ease of understanding, while the second part of the Circular presents the raw tabulations upon which the summaries are based.

It is anticipated that this Fixed Highway Lighting survey represents but the first of a series of such questionnaires designed to provide current data on operational practices related to visibility. The results of future surveys by the Visibility Committee will be published as they become available.

Albert Burg

Section I

SUMMARY OF RESPONSES

SECTION I - SUMMARY OF RESPONSES

Not all 49 respondents answered every question. In these cases, the "(N=x)" after the question gives the total number of responses to that question. A complete tabulation of all questionnaire responses will be found in SECTION II AND III.

Question 1. Describe a typical new highway lighting system designed and used by your State Highway Department or Department of Transportation.

a. MAINLINE, CONVENTIONAL INSTALLATION (N=48)

1) Lamp & Wattage:

Lamp	175w	400w	700w	1000w	various comb.	* NS
MV (mercury vapor)	--	11	8	6	9	5
MH (metal halide)	--	1	--	--	--	--
HPS (high pressure sodium)	1	11	--	--	1	3

2) Mounting Height:

Range of responses : 30' to 60'
Most common responses: 40' (N=12); 50' (N=12)
Average height : 42.6'

3) Average Maintained Footcandles:

Range of responses : 0.5 to 4.0 fc
Most common responses: 0.6 to 0.8 (N=30)
Average fc : 0.85

4) Maximum Uniformity Ratio:
(Average/Minimum)

Range of responses : 2:1 to 6:1
Most common responses: 3:1 to 4:1 (N=40)
Average UR : 3.4:1

b. MAINLINE, HIGH MAST INSTALLATION (N=30)

1) Lamp & Wattage:

Lamp	400w	1000w	var. comb.	NS
MV	1	4	--	--
MH	--	21	--	2
HPS	6	1	1	--

2) Mounting Height:

Range of responses : 50' to 160'
Most common responses: 100' (N=12)
Average height : 111.4'

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* NS = wattage not specified

3) Average Maintained Footcandles:

Range of responses : 0.2 to 1.5 fc
Most common responses: 0.6 to 0.8 (N=20)
Average fc : 0.69

4) Maximum Uniformity Ratio:

Range of responses : 2.5:1 to 6:1
Most common responses: 3:1 to 4:1 (N=22)
Average UR : 3.4:1

c. RAMPS, CONVENTIONAL INSTALLATION (N=47)

1) Lamp & Wattage:

	175w	250w	400w	700w	1000w	var. comb.	NS
MV	--	--	19	3	3	11	6
MH	--	--	1	--	--	--	--
HPS	1	1	7	--	--	2	2

2) Mounting Height:

Range of responses : 30' to 60'
Most common responses: 30' (N=9); 40' (N=10); 50' (N=7)
Average height : 39.4'

3) Average Maintained Footcandles:

Range of responses : 0.2 to 6.0 fc
Most common responses: 0.6 to 0.8 (N=31)
Average fc : 0.83

4) Maximum Uniformity Ratio:

Range of responses : 2:1 to 6:1
Most common responses: 3:1 to 4:1 (N=39)
Average UR : 3.5:1

d. RAMPS, HIGH MAST INSTALLATION (N=25)

1) Lamp & Wattage:

	400 w	1000w	NS
MV	2	3	--
MH	--	17	2
HPS	5	--	--

2) Mounting Height:

Range of responses : 50' to 160'
Most common responses: 100' (N=10)
Average height : 113.6'

3) Average Maintained Footcandles:

Range of responses : 0.2 to 1.25 fc
Most common responses: 0.6 to 0.8 (N=17)
Average fc : 0.65

4) Maximum Uniformity Ratio:

Range of responses : 2.5:1 to 6:1
Most common responses: 3:1 (N=11)
Average UR : 3.4:1

e. CROSSROAD, CONVENTIONAL INSTALLATION (N=47)

1) Lamp & Wattage:

	250w	400w	700w	1000w	var. comb.	NS
MV	--	20	2	2	10	7
MH	--	1	--	--	--	--
HPS	1	7	--	--	2	1

2) Mounting Height:

Range of responses : 27' to 60'
Most common responses: 30' (N=10); 40' (N=11)
Average height : 32.5'

3) Average Maintained Footcandles:

Range of responses : 0.5 to 8.0 fc
Most common responses: 0.6 to 0.8 (N=25)
Average fc : 0.91

4) Maximum Uniformity Ratio:

Range of responses : 2:1 to 6:1
Most common responses: 3:1 to 4:1 (N=40)
Average UR : 3.5:1

f. CROSSROAD, HIGH MAST INSTALLATION (N=19)

1) Lamp & Wattage:

	400w	1000w	var. comb.	NS
MV	--	3	1	--
MH	--	12	--	2
HPS	4	--	--	--

2) Mounting Height:

Range of responses : 50' to 150'
Most common responses: 100' (N=8)
Average height 109.9

3) Average Maintained Footcandles:

Range of responses	:	0.2 to 2.0 fc
Most common responses	:	0.6 to 0.8 (N=14)
Average fc	:	0.69

4) Maximum Uniformity Ratio:

Range of responses	:	2.5:1 to 6:1
Most common responses	:	3:1 (N=9)
Average UR	:	3.4:1

g. POWER SUPPLY VOLTAGE USED IN TYPICAL LIGHTING SYSTEM

120/240 ------------- 4
120/208 ------------ 1
240/480 ------------ 26
277/480 ------------ 3
120/240, 240/480 ----- 9
480 ------------------ 2
Other combinations --- 4

Question 2. What type of light source do you favor for future use in highway lighting? (Number in order of preference)

Light Source	No. of Respondents Ranking This Item	Mean Rank	No. of Respondents Giving Rank of One
Mercury Vapor	46	1.65	23
Metal Halide	37	2.46	4
Fluorescent	18	4.55	0
High Pressure Sodium	45	1.80	21
Low Pressure Sodium	19	3.74	1

Question 3. What type of light source do you use for sign lighting? (Number in order of predominance)

a. Present Use		b. Future Use
17	Mercury Vapor	33
28	Fluorescent	6
0	Both of the above	1
0	Multi Vapor	3
1	High Pressure Sodium	3
3	NR*	3

*No response

Question 4. Who is responsible for the highway lighting design work in your State?

a.	In-house Staff (unspecified) or otherwise unspecified-----	5
b.	In-house Staff: Illumination Engineer -------------------	2
c.	In-house Staff: Electrical Engineer ---------------------	8
d.	In-house Staff: Traffic Engineer ------------------------	12
e.	In-house Electrical Engineer plus Consultant Firm --------	6
f.	In-house Traffic Engineer plus Consultant Firm -----------	3
g.	In-house Elect. and Traffic Engineers plus Consult. Firm -	4
h.	Other combinations of the above --------------------------	9

Question 5. Who owns a completed highway lighting system after it has been installed by the State?

		Interstate	Other Roads
a.	Owned by State -----------------------	41*	27**
b.	Owned by County or Municipality -------	1***	2
c.	Owned by Utility Company---------------	2	4
d.	State plus Co. or Munic.---------------	2	7
e.	State plus Utility Co. ----------------	1	1
f.	County or Munic. plus Utility Co.------	--	2
g.	Owned by all three --------------------	--	2
h.	NR /1 ---------------------------------	1	3

* plus one "outside city limits only"
** plus one "except for luminaires and lamps"
*** plus one "inside city limits only"
/1 No Response

Question 6. Indicate the percentage of the installation cost and the annual energy and maintenance costs paid by the county or municipality and by the State for a highway lighting system installed by the State.

INSTALLATION COST:

County or Municipality % / State %	Interstate	Other Roads
0 / 100 -----	42	24
5 / 95 -----	3	--
10 / 90 -----	2	--
25 / 75 -----	--	3
50 / 50 -----	--	10
100 / 0 -----	--	6
Other Combinations-	--	2
NR or NA ----------	2	4

ENERGY COST:

County or Municipality % / State %		Interstate	Other Roads
	100 / 0	10	23
	50 / 50	1	4
	0-5 / 95-100	34	16
100 / 0 within city limits and 0 / 100 outside city limits		2	2
	NR or NA	2	4

MAINTENANCE COST:

County or Municipality % / State %		Interstate	Other Roads
	100 / 0	10	19
	80 / 20	--	1
	50 / 50	1	4
	0-5 / 95-100	34	19
100 / 0 within city limits and 0 / 100 outside city limits		2	2
	NR or NA	2	4

Question 7a. Who is responsible for normal highway lighting maintenance for a system which has been installed by the State on an Interstate route?

State	26	State + Utility Company	4
County	0	State + Municipality	3
Municipality	6	County + Municipality	1
Utility Company	7	Municipality + Utility Company	1
		Not Applicable (D.C.)	1

Question 7b. Who is responsible for normal highway lighting maintenance for a system which has been installed by the State or other than an Interstate route?

State	10	State + Utility Company	4
County	1	State + Municipality	7
Municipality	10	County + Municipality	3
Utility Company	5	Other Combinations	7
		Not Applicable (D.C.)	1
		NR	1

Question 8a. At what intervals are the luminaires cleaned on a highway lighting system which has been installed by the State?

0.5 years - 1	2-4 years - 2	NR - 4
1.0 " - 11	3.0 " - 3	
1.5 " - 1	4.0 " - 5	
1.6 " - 1	Other - 3	
2.0 " - 6	At Burn Out - 3	
2.5 " - 1	No Scheduled Cleaning - 8	

Question 8b. At what intervals are the luminaires group relamped on a highway lighting system which has been installed by the State?

Mercury Vapor	Multi Vapor/Metal Halides	High Pressure Sodium
2.0 years - 2	1-2 years - 1	1.0 years - 1
3.0 " - 6	1.5 " - 4	1.6 " - 1
4.0 " - 17	1.5-2 " - 1	2.0 " - 5
5.0 " - 3	2.0 " - 2	3.0 " - 1
5.25 " - 1	2.2 " - 1	
5.5 " - 1	2.5 " - 1	
Burn Out - 5	------------- 3	----------- 5
No Schedule - 6	------------- 7	----------- 8
NR ---------8	------------- 29	----------- 28

Question 9. What is your highway lighting design primarily based on?

a. Average Maintained Horizontal Footcandles--------------- 5
b. Average Maintained Vertical Footcandles ---------------- 0
c. Uniformity Ratio --------------------------------------- 3
d. Luminance -- 1
e. Glare -- 0
f. a. plus c. above --------------------------------------- 30
g. a. plus c. plus e. above ------------------------------- 3
h. Other combinations of the above ------------------------ 7

Question 10. How do you take glare into consideration in your highway lighting designs?

State-by-state answers to this question will be found in SECTION III.

Question 11. Approximately what is the energy cost per kilowatt-hour for your highway lighting system? (N=42)

Range of responses - 1 to 17 cents per KWH
Average cost ------- 2.15 ¢/KWH

Question 12. If you have had experience with high mast lighting installations (e.g., 80 ft. or higher) in your State, please furnish the following information:

a. TYPE OF SUPPORT: (N=36)

Tower---------- 2
Pole ---------- 29
Both ---------- 2
Not Specified - 3

Question 12. (cont'd)

b. LAMP TYPE: (N=36)

MV	- 2	MH/MV	- 2
MH	- 24	MH/HPS	- 2
HPS	- 4	NR	- 2

c. LAMP WATTAGE: (N=36)

400w - 3
1000w - 30
400/1000w - 3

d. MOUNTING HEIGHT: (N=36)

Range of responses : 80' to 160'
Most common responses : 100' (N=10)
Average height : 113.3'

e. MAXIMUM CP ANGLE: (N=30)

Range of responses : 45° to 85°
Most common responses : 60° to 65° (N=15)
Average of responses : 63.8°

f. LUMINAIRES PER TOWER: (N=35)

Range of responses : 3 to 16
Most common responses: 6 to 8 (N=16)
Average # luminaires: 6.78

g. AVERAGE TOWER SPACING: (N=32)

Range of responses : 350' to 750'
Average of responses: 543'

h. AVERAGE INITIAL FOOTCANDLES: (N=33)

Range of responses: 0.2 to 3.5 fc
Average of responses: 1.05 fc

i. UNIFORMITY RATIO: (N=31)

Range of responses: 2:1 to 6:1
Most common response: 3:1 (N=13)
Average UR : 3.3:1

j. NUMBER OF HIGH MAST INSTALLATIONS: (N=42)

Range of responses: 0 to 69
Average of responses: 6.3 installations

Question 13. If you have recently completed or are now completing any new lighting installations incorporating novel or experimental features, please describe.

State-by-state answers to this question will be found in SECTION III.

Question 14a. Where new lighting is installed on new poles, are all unprotected of the break-away type?

Yes - 45 No - 4

Question 14b. Do you have a program to replace older unprotected and unyielding poles with the break-away type?

Yes - 31 No - 14 Not Applicable - 4

Section II

TABULATION OF RESPONSES TO QUESTIONS 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 14

MAINLINE

	Question 1a—Conventional						Question 1b—High Mast					
	Type Lamp			Mounting	Avg. Maint.	Max.	Type Lamp			Mounting	Avg. Maint.	Max.
State	MV	Met. H	HPS	Ht. (ft)	fc.	UR	MV	Met. H	HPS	Ht. (ft)	fc.	UR
Alabama			400	50	.6	4:1			400	90-120	.6	4:1
Alaska			400	40	1.5	3:1						
Arizona	700			50	.8	2:1						
Arkansas	400			40	.6-.8	3:1	1000			50	.6-.8	3:1
California	700			40	.8	4:1			400	100	.8	4:1
Colorado	700			40	.6-.8	3:1						
Connecticut	400			30-50	.6-.8	3-4:1		1000		100	.6-.8	3-4:1
	700											
	1000											
Delaware	400		400	30-40	.65-1.1	4:1	400	1000		160	.74	3:1
Florida	700			40	1.2[a]	3:1						
Georgia	400			35-45	1.2	3:1		1000		100		3:1
	1000											
Hawaii	√			30-45		4:1						
Idaho			√	50	.9	3:1						
Illinois		400		50	.6	3:1	1000	1000		110	.2	2.5:1
Indiana			400	45	.9	3:1						
Iowa	400			40	.6	3:1		1000		100-150	.2-.3	3:1
Kansas	1000			50	.8-1.2	3:1		1000		100	.6-.8	3:1
Kentucky	700			40	.6	3:1						
Louisiana	400			35-50	.6-.8	3:1		1000		120	.6-.8	3:1
	700											
Maine	400			40	.6	3:1						
Maryland								1000		90-115	.6	3-4:1
Michigan	1000			40-45	1[a]	3-4:1		1000		80-110	.2 min.	—
Minnesota	√			40-50	.6	6:1		√		100-140	.6	6:1
Mississippi			400	50	.6-.8	4:1			400	100	.6-.8	4:1
Missouri	700			45	.6	4:1						
Montana	√			40	.6	4:1						
Nebraska	1000			50	.8-1.4	4:1		1000		150	.8	3:1
Nevada	400			32	.8	4:1		1000		100	.8	
New Hampshire	√			40	.8	3:1		√		100	.7	3:1
New Jersey	400		175	40	.6-.8	4:1		1000		100	.6	4:1
New Mexico			√	50	1.0	3:1						
N. Carolina	1000			50	.6-.8	3-4:1		1000		100		
N. Dakota	700		250	40-50	.6-.8	3-4:1		1000		120-140	.6-.8	3-4:1
	1000		400									
Ohio	700			41.7	.6	4:1		1000		100	.6	3:1
Oklahoma	400			40-50	.6	4:1		1000		150	.6	4:1
	1000											
Oregon	400			50	.6-2	2-4:1		1000	400	80-150	.6-1.25	3:1
	700											
	1000											
Pennsylvania	700			35-40	.8	4:1		1000		100	.8	4:1
	1000											
Rhode Island	400			30	.8	3:1		1000		100+	.6	3:1
S. Carolina	400			30	.6	4:1						
S. Dakota	400		400	40-60	.5-1	3:1		1000	400	80-150	.5-1	3:1
									1000			
Tennessee	700			45	0.6	3:1						
Texas	1000		400	50			1000		400	150		
Utah	400		400	40-45	0.8							
Vermont			√	40	0.9	3-4:1						
Virginia	√			30-50	0.8	4:1						
Washington	1000			50	0.6	2,5:1						
W. Virginia	400		400	32-50	.8-1.5	4-6:1		1000	400	90-100	1.0	4-6:1
	700											
	1000											
Wisconsin	-[b]	-[b]	400		1.0-1.2	2.5:1			1000	50-150	1.5	2.5:1
Wyoming	400			30-40	.8	3:1	1000			150	.8	3:1
	700											
District of Columbia	400		400	30-40	1-4	3:1						

[a]Avg. init. fc. [b]1000 W - other type.

RAMPS

State	Question 1c—Conventional						Question 1d—High Mast					
	Type Lamp			Mounting Ht. (ft)	Avg. Maint. fc	Max. UR	Type Lamp			Mounting Ht. (ft)	Avg. Maint. fc	Max. UR
	MV	Met. H	HPS				MV	Met. H	HPS			
Alabama			250- 400	35-50	.6	3-4:1			400	90-120	.6	3-4:1
Alaska												
Arizona	400			30	.7	3:1						
Arkansas	400			40	.6-.8	3:1	400			50	.6-.8	3:1
California	400			30	.8	4:1						
Colorado	700			40	.6-.8	3:1		1000		100	.6-.8	3:1
Connecticut	400 700			30-40	.6-.8	3-4:1		1000		100	.6-.8	3-4:1
Delaware	400		400	30-40	.65-1.1	4:1	400	1000		160	.75	3:1
Florida	400			40	1.2[a]	4:1						
Georgia	175 400			35-40		3:1						
Hawaii	√			30		4:1						
Idaho			√	50	.9	3:1						
Illinois		400		50	.6	3:1	1000	1000		110	.2	2.5:1
Indiana			400	45	.9	3:1						
Iowa	400			40	.6	3:1		1000		100-150	.2-.3	3:1
Kansas	400			40	.4-.6	4:1		1000		100	.4-.6	3:1
Kentucky	400			30	.6	3:1						
Louisiana	400 700			35-50	.6-.8	3:1		1000		120	.6-.8	3:1
Maine	400 250 175			40	.6	3:1						
Maryland								1000		90-115	.6	3.4:1
Michigan	400 1000			35-45	1[a]	3-4:1		1000				
Minnesota	√			40-50	.6	6:1		√		100-120	.6	6:1
Mississippi			250	50	.6-.8	4:1			400	100	.6-.8	4:1
Missouri	400			45	—	—						
Montana	√			40	.6	4:1						
Nebraska	1000			50	.6	4:1		1000		150	.2-.6	3:1
Nevada	400			32	.8	4:1		1000		100	.8	
New Hampshire	√			40	.8	3:1		√		100	.7	3:1
New Jersey	400		175	40	.6-.8	4:1		1000		100	.6	4:1
New Mexico			√	50	1.0	2.6:1						
N. Carolina	1000			35	.6-.8	3-4:1						
N. Dakota	700 1000		250 400	40-50	.6-.8	3-4:1		1000		120-140	.6-.8	3-4:1
Ohio	400			34.2	.6	4:1						
Oklahoma	400 1000			40-50	.6	4:1		1000		150	.6	4:1
Oregon	400 700 1000			50	.6-2	2-4:1		1000	400	80-150	.6-1.25	3:1
Pennsylvania	400			30	.8	4:1		1000		100	.8	4:1
Rhode Island	400			30	.8	3:1		1000		100+	.6	3:1
S. Carolina	400			30	.6	4:1						
S. Dakota	400		400	40-60	.5-1	3:1						
Tennessee	700			45	0.6	3:1						
Texas	1000		400	50			1000		400	150		
Utah	400		400	40-45	0.8							
Vermont	√			30	0.6-0.8							
Virginia	√			30	0.8	4:1						
Washington	700			40	0.6	2.5:1						
W. Virginia	400 700		400	30-40	1.0	4:1			400	100	1.0	
Wisconsin	250 400			32	1.0-1.2	4:1						
Wyoming	400 700			30-40	.8	3:1	1000			150	.8	3:1
District of Columbia	400		400	30-40	2-6	4:1						

[a]Avg. init. fc.

CROSSROAD

State	Question 1e—Conventional						Question 1f—High Mast					
	Type Lamp			Mounting Ht. (ft)	Avg. Maint. fc.	Max. UR	Type Lamp			Mounting Ht. (ft)	Avg. Maint. fc.	Max. UR
	MV	Met. H	HPS				MV	Met. H	HPS			
Alabama			200-400	35-50	.9-2.0	3-4:1			400	90-100	.9-2.0	3-4:1
Alaska			250	40	1.0	3:1						
Arizona	400			30	.7	3:1						
Arkansas	400			40	.6-.8	3:1	400-1000			50	.6-.8	3:1
California	400			30	.8	4:1						
Colorado	700			40	.6-.8	3:1		1000		100	.6-.8	3:1
Connecticut	400			30	.6-.9	3-4:1						
Delaware	400			30	.65-1.0	4:1						
Florida	400			40	1.2[a]	3:1						
Georgia	400			35-40		3:1						
Hawaii	√			30		3-4:1						
Idaho	√			50	.9	3:1						
Illinois		400		50	.6	3:1	1000	1000		110	.2	2.5:1
Indiana			400	45	.9	3:1						
Iowa	400			40	.6	3:1		1000		100-150	.2-.3	3:1
Kansas	400			40	.5-.8	4:1		1000		100	.6-.8	3:1
Kentucky	400 700			30-40	.6	3:1						
Maine	400 250 175			40	.6	3:1						
Maryland								1000		90-115	.6	3-4:1
Michigan	400			30	1.2[a]	3-4:1						
Minnesota	√			30-50	.6	6:1		√		100-120	.6	6:1
Mississippi			400	50	.6-.8	4:1			400	100	.6-.8	4:1
Missouri	400			45	-	-						
Montana	√			40	.6	4:1						
Nebraska	1000		400	40-50	.6-1.2	4:1		1000		100	.6	3:1
Nevada	400			32	.8	4:1		1000		100	.8	
New Hampshire	√			40	.8	3:1		√		100	.7	3:1
New Jersey	250 400			27-40	1	4:1						
New Mexico			√	40	1.27	2.7:1						
N. Carolina	400			35	.6-.8	3-4:1						
N. Dakota	700 1000		250 400	40-50	.6-.8	3-4:1		1000		120-140	.6-.8	3-4:1
Ohio	400			34.2	.6	4:1						
Oklahoma	400 1000			40-50	.6	4:1		1000		150	.6	4:1
Oregon	400 700 1000			50	.6-2.0	2-4:1		1000	400	80-150	.6-1.25	3:1
Pennsylvania	400 700			30-35	.8	4:1		1000		100	.8	4:1
Rhode Island	400			30	.8	3:1		1000		100+	.6	3:1
S. Carolina	400			30	.6	4:1						
S. Dakota	400		400	40-60	.5-1	3:1						
Tennessee	400			35	0.6	3:1						
Texas	1000		400	50			1000		400	150		
Utah	400		400	35-40	0.8-2.0							
Vermont	√			30	0.6-0.8	4:1						
Virginia	√			30	0.8	4:1						
Washington	700			40	0.6	2.5:1						
W. Virginia	400 700			30-40	1.0	4:1						
Wisconsin	250 400			32	1.0	4:1						
Wyoming	400 700			30-40	.8	3:1	1000			150	.8	3:1
District of Columbia	400		400	30-40	1-8	3:1						

[a]Avg. init. fc.

State	Question 1g—Power Supply Voltage	Question 2—Future Hwy. Lighting					Question 3a—Present Sign Lighting			Question 3b—Future Sign Lighting		
		MV	Met. H	Fluor	HPS	LPS	MV	Fluor	Met. H	MV	Fluor	Met. H
Alabama	C	3	4	-	1	2	√			√		
Alaska	C	3	2	4	1	5	-			-[a]	-[a]	-[a]
Arizona	C	1	2	5	3	4		√			√	
Arkansas	A, C	1	2	-	3	-		√			√	
California	A, C	1	3	-	2	-		√		√		
Colorado	C	1	1	-	2	-		√		√		
Connecticut	C	1	3	5	2	4	√			√		
Delaware	C	3	2	-	1	-	√			√		
Florida	C	-	-	-	1	-		√		√		
Georgia	A, C	1	2	-	3	-	√			√		
Hawaii	A, C, D	1	3	5	2	4		√		√		
Idaho	C	2	-	-	1	-		√		√		
Illinois	C	2	3	5	1	4	√			-[a]	-[a]	-[a]
Indiana	C	2	-	-	1	?	√			√		
Iowa	A	2	3	-	1	-	-			√		
Kansas	C	1	2	4	3	5		√		√		
Kentucky	C	2	3	5	1	4		√			√	
Louisiana	C	2	1	4	3	5	√					√
Maine	B, C	1	2	-	3	-	√			√		
Maryland	D	2	3	-	1	-	√			√		
Michigan	A, C	1	2	3	4	-		√			√	
Minnesota	C	2	3	5	1	4		√		√		
Mississippi	C	2	-	-	1	-	√			√		
Missouri	C	1	-	-	2	-	√			√		
Montana	A	1	3	-	2	-	√			-		
Nebraska	C	1	3	5	2	4	√					
Nevada	A, C	1	3	-	2	-		√			√	
New Hampshire	A	2	1	-	3	-	√			√		
New Jersey	D	1	2	-	3	-	√			√		
New Mexico	C	2	3	4	1	-		√		√		
N. Carolina	C	1	2	-	3	-		√			√	
N. Dakota	A, C	1	3	-	2	-		√		√		
Ohio	C	4	2	-	1	3		√		√		
Oklahoma	E	1	2	5	3	4		√		√		
Oregon	A, C	3	1	-	2	-		√				√
Pennsylvania	C	2	3	5	1	4	√			√		
Rhode Island	C, D	1	-	-	-	-		√		√		
S. Carolina	C	1	2	-	-	-		√		√		
S. Dakota	C	2	3	5	1	4				√		
Tennessee	A, C	1	3	5	2	4		√		√		
Texas	C	3	-	-	2	1		√		√		
Utah	A, C	2	4	5	1	3	-[a]	-[a]	-[a]	-[a]	-[a]	-[a]
Vermont	A	√	-	-	-	√		√				
Virginia	D	2		3	1	-		√				
Washington	E	1	2	-	-	3[c]		√		√		
W. Virginia	B, C, D	2	3	-	1	-		√		√		
Wisconsin	E	2	-	-	1	-		√		√		
Wyoming	C	1	-	-	2	-	√			√		
District of Columbia	B	-	-	-	1	-		√		√	√	

Note: A = 120/240, B = 120/208, C = 240/480, D = 277/480, E = 480, (√) = in house staff (unspecified) or other, O.C. = outside city limits, I.

[a]HPS. [b]Except for luminaires and lamps. [c]4th choice—tin. chloride molecular ARC lamp.

Question 4—Hwy. Lighting Design					Question 5—Owns Hwy. Lighting Sys.						
					Other			Inter.			
Illum. Engr.	Elect. Engr.	Traffic Engr.	Con-sultant	Utility Co.	State	Co. or Munic.	Util. Co.	State	Co. or Munic.	Util. Co.	State
	√		√		√			√			Alabama
		√			√			√			Alaska
		√			√			√			Arizona
		√				√			√		Arkansas
		√			√			√	√		California
√					√			√			Colorado
	√	√			√			√			Connecticut
	√	√	√		√			√	√	√	Delaware
√					√			√			Florida
√	√				√			√			Georgia
		√	√		√			√			Hawaii
		√			√			√	√		Idaho
	√				√			√	√		Illinois
	√		√		√			√			Indiana
√					√	√		√			Iowa
√	√	√			√			√			Kansas
	√	√	√		√			√			Kentucky
	√				√			√			Louisiana
	√				√			–[b]			Maine
	√		√	√	√			√	√	√	Maryland
	√		√		√			–			Michigan
		√			√			√			Minnesota
	√				√			√			Mississippi
	√				√			√			Missouri
	√				√			√			Montana
√							√			√	Nebraska
		√			√			–	–	–	Nevada
√							√			√	New Hampshire
	√		√		√			√			New Jersey
		√			√				√	√	New Mexico
√		√	√		√			√			N. Carolina
		√			√			√			N. Dakota
√	√		√		O.C.	I.C.		√			Ohio
√			√	√	√			√			Oklahoma
√					√			√	√		Oregon
	√		√		√				√		Pennsylvania
		√	√		√		√	√		√	Rhode Island
			√	√	√			√			S. Carolina
		√			–						S. Dakota
	√	√	√		√					√	Tennessee
√					√	√		√	√		Texas
	√				√				√	√	Utah
		√			√			√	√		Vermont
	√	√	√		√					√	Virginia
		√			√			√			Washington
		√	√		√			√			W. Virginia
	√	√			√			√	√		Wisconsin
	√				√			√			Wyoming
	√		√		O.C.			O.C.			District of Columbia

C. = inside city limits.

State	Question 6—Cost											
	Installation (%)				Energy (%)				Maintenance (%)			
	Inter.		Other		Inter.		Other		Inter.		Other	
	Co. or Munic.	State	Co. or Munic.	State	Co. or Munic.	State	Co. or Munic.	State	Co. or Munic.	State	Co. or Munic.	State
Alabama	0	100	50	50	100	0	100	0	100	0	100	0
Alaska	0	100		100		100	100			100	100	
Arizona	0	100	50	50		100	100			100	100	
Arkansas	0	100	100		100		100		100		100	
California	0	100	50	50		100	50	50		100	50	50
Colorado	0	100		100	100		100			100		100
Connecticut	0	100		100		100		100		100		100
Delaware	0	100		100		100		100		100		100
Florida	0	100		100		100	100			100	100	
Georgia	0	100		100		100	100			100	100	
Hawaii	0	100		100		100		100		100		100
Idaho	0	100		100		100	100			100	100	
Illinois	0	100		100		100	100			100	100	
Indiana	0	100	100		100		100		100		100	
Iowa	0	100		100	100 I.C.	100 O.C.		100	100 I.C.	100 O.C.		100
Kansas	0	100		100		100	100			100	80	20
Kentucky	0	100		100		100		100		100		100
Louisiana	0	100	100		100		100		100		100	
Maine	0	100		100[a]		100	100		100			100[c]
Maryland	0	100		100		100		100		100		100
Michigan	0	100		0		100		0		100		0
Minnesota	0	100	25	75	2	98	50	50	2	98	50	50
Mississippi	0	100		100		100		100		100		100
Missouri	10	90	50	50	100		100		100		100	
Montana	0	100		100		100		100		100		100
Nebraska	5-0	95-100		50-100		100		100		100		100
Nevada	0	100		100		100	100			100	100	
New Hampshire	0	100		100	1	99	5	95	1	99	5	95
New Jersey	0	100		100		100		100		100		100
New Mexico	0	100	50	50	100		100		100		100	
N. Carolina	0	100		100		100		100		100		100
N. Dakota	0	100	25	75		100	100			100	100	
Ohio	5	95	50	50		100	100 I.C.	100 O.C.		100	100	100 O.C.
Oklahoma	10	90	50	50	100		100		100		100	
Oregon	0	100	S	S		100	S	S		100	S	S
Pennsylvania	0	100		100		100	50	50		100	50	50
Rhode Island												
S. Carolina	0	100		100	100			100	100			100
S. Dakota	0	100	100-0	0-100	100 I.C.	100 0.C.	100 I.C.	100 O.C.	100 I.C.	100 O.C.	100 I.C.	100 O.C.
Tennessee	0	100	100		100		100		100		100	
Texas	5	95	50	50	50	50	50	50	50	50	50	50
Utah	0	100	25	75		100	100			100	100	
Vermont	0	100	50	50		100		100		100		100
Virginia	0	100		100		100		100		100		100
Washington	0	100		100		100		100		100		100
W. Virginia	0	100	50	50		100	100			100		100
Wisconsin	0	100	-	-		100	-	-		100	-	-
Wyoming	0	100	100			100	100			100	100	
District of Columbia	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Note: B.O. = at burn out, I.C. = inside corp. (city) limits, O.C. = outside corp. (city) limits, S = special—see questionaire, N = no scheduled cleaning, [a]Except luminaires and lamps. [b]4 yrs. MV, 3 yrs. HPS. [c]4 yrs. MV, 1.5 yrs. MH.

Question 7a—Maintenance Responsibility, Interstate				Question 7b—Maintenance Responsibility, Non-Interstate				Question 8a— Luminaires Cleaned (Yr.)	
State	County	Munici-pality	Utility Co.	State	County	Munici-pality	Utility Co.		State
		√				√		3	Alabama
√				√		√		N	Alaska
√			√	√	√	√		1	Arizona
		√				√		N	Arkansas
√				√				2	California
			√	√			√	N	Colorado
√				√				1	Connecticut
√				√		√	√	N	Delaware
√					√			-	Florida
√					√	√		2	Georgia
√				√			√	1.5	Hawaii
√						√		B.O.	Idaho
√				√	√	√		1	Illinois
		√				√		1	Indiana
			√				√	2-4	Iowa
√				√		√		1	Kansas
√				√				N	Kentucky
		√				√		4	Louisiana
√				√		√		4	Maine
			√				√	4	Maryland
√				-				1	Michigan
√			√	√	√	√	√	1	Minnesota
√				√				B.O.	Mississippi
		√				√		.5	Missouri
√				√				2	Montana
		√	√			√	√	1	Nebraska
√					√	√	√	2	Nevada
			√				√	-[c]	New Hampshire
√				√				3	New Jersey
		√				√		-	New Mexico
√				√				N	N. Carolina
√						√		2	N. Dakota
√		√		√		√		1	Ohio
	√	√			√	√		-	Oklahoma
√					√	√		0	Oregon
√						√		2	Pennsylvania
√			√				√	4	Rhode Island
			√	√			√	-	S. Carolina
√		√		√		√		2-4	S. Dakota
			√				√	-[b]	Tennessee
√		√		√		√		N	Texas
			√		√	√	√	1.6	Utah
√				√		√		N	Vermont
√				√				1	Virginia
√				√				2.5	Washington
√						√		B.O.	W. Virginia
√				√				4	Wisconsin
√			√	√			√	3	Wyoming
O.C.				O.C.				1	District of Columbia

NA = not applicable.

State	Question 8b—Luminaries Relamped (Yr.) MV	Met. H	HPS	Question 9—Hwy. Lighting Based On: Avg. Maint. Horiz. fc	Avg. Maint. Vert. fc	Uniformity Ratio	Luminance	Glare	Question 11—Energy Cost per KWH (¢)	Question 12—High Mast Lighting: Tower	Pole	Height (ft.)	Type Lamp
Alabama	3	-	N	√		√			1		√	90-120	HPS
Alaska	N	N	N	√		√			5-17				
Arizona	-	-	-	√					-		√	100	MH
Arkansas	N	N	N	√		√			-	√		100-150	
California	2	-	-	√					3		√	100	HPS
Colorado	N	N	N	√		√			-		√	100-120	MH
Connecticut	3	-	-	√		√			2.4		√	100	MH
Delaware	5	-	-	√		√			2.1		√	160	MH
Florida	-	-	-	√[a]		√			1.7		√	100	MH
Georgia	4	-	-	√		√			1.5		√	100-120	MH
Hawaii	B.O.	-	-	√		√			1.5				
Idaho	B.O.	-	B.O.			√		√	2				
Illinois	4	1-2	2	√		√			3		√	110	MH
Indiana	2	-	1	√		√			1.35				
Iowa	4	1.5	-	√		√			1.5		√	140	MH
Kansas	4	1.5	-	√	√	√	√	√	2		√	100	MH
Kentucky	N	N	N	√		√			2				
Louisiana	4	N	N	√		√			2		√	120	MH
Maine	4	-	-	√		√			2.95				
Maryland	4	-	-			√			3.2		√	90-115	MH
Michigan	4	-	2	√		√		√	1.5		√	80-110	MH
Minnesota	-	2	-	√		√		√	2.3		√	100-140	MH
Mississippi	B.O.	B.O.	B.O.	√		√			1.87		√	100	HPS
Missouri	5.25	-	-			√			1				
Montana	4	-	2	√		√			1.716				
Nebraska	3	-	-	√		√			1.5-2.5		√	100-140	H
Nevada	4	-	-	√		√			1-4		√	100	MH
New Hampshire	4	1.5	-	√		√			6.825[c]			80-100	MH
New Jersey	3	1.5		√		√			2.8-4.24		√	100	MH
New Mexico	-	-	-	√		√			-		√	120	MH
N. Carolina	-	-	-	√		√			2		√	100-120	MV MH
N. Dakota	4	-	-	√		√			2.9	√		140	MV
Ohio	4	2	-	-[e]		√			2.2		√	80-120	MH
Oklahoma	-	-	-	√		√			-			100-150	MH
Oregon	B.O.	B.O.	B.O.	√	√	√			1		√	80-150	HPS MH
Pennsylvania	4	1.5-2	B.O	√		√			2.2		√	100	MH
Rhode Island	4	-	-	√	√	√	√	√	2.5		√	120-135	MH
S. Carolina	-	-	-	√					1.5				
S. Dakota	5	2.2	-	√		√		√	2	√	√	80-150	MH MV
Tennessee	4	-	3	√		√			1.36		√	100	
Texas	N	N	N			√	√	√	1-2	√	√	100-150	MV
Utah	-	-	1.6	√					1.75				
Vermont	N	N	N	√		√			-				
Virginia	5.5	-	-			√			1				
Washington	5	25	2	√					1.2		√	103	MH
W. Virginia	B.O.	B.O.	B.O.	√		√			1.9-2.1		√	90-140	HPS MH
Wisconsin	4	-	-				√		1.25-2.5			100-150	HPS
Wyoming	3	-	-	√		√			2		√	150	MH
District of Columbia	3	-	2	√		√			1.5				

Note: B.O. = at burn out, N = no scheduled relamping.

[a]Avg. init. fc. [b]No significant no. of unyielding poles in use. [c]Includes maintenance, lamps, luminaires, poles, wiring, etc. [d]No. breakaway poles have been used ex

Lamp Wattage	Max. CP Angle	Luminaires per Tower	Avg. Tower Spacing	Avg. Initial fc	Uniformity Ratio	No. Installations	Question 14a— New Ltg.-Frangible Base	Question 14b— Replace w/Frangible Base	State
400	67	8-10	400	1.0	2:1	4	Yes	No	Alabama
							Yes	Yes	Alaska
1000	45		600			3	Yes	Yes	Arizona
1000		6-10		.2		1	Yes	Yes	Arkansas
400	70	8	500	1	4:1	1	Yes	Yes	California
1000	63	6-8	700	1.0	3:1	2	Yes	Yes	Colorado
1000		4	500			1	Yes	Yes	Connecticut
1000	75	16	750	1.2	2.5:1	1	Yes	-[b]	Delaware
1000	60	6	600-650	.3	2:1	3	Yes	Yes	Florida
1000	55	6	500-600	1.43	3:1	4	Yes	Yes	Georgia
						0	Yes	Yes	Hawaii
							Yes	Yes	Idaho
1000	60	2.6	400	.5	2.5:1	3	Yes	Yes	Illinois
							Yes	No	Indiana
1000	65	8	700	.3	3:1	5	Yes	No	Iowa
1000	62	6	600	.4-.6	3:1	9	Yes	Yes	Kansas
							Yes	Yes	Kentucky
1000		8	500	1.0	3:1	1	Yes	No	Louisiana
						0	Yes	No	Maine
1000	68	3-8	400	1.05	3.4:1		Yes	Yes	Maryland
1000	80	8 max.	600	.2 min.	-	69	Yes	Yes	Michigan
1000	63	6-10	600	1.0	6:1	5	Yes	Yes	Minnesota
400	63	6-7	486	1.3	3.6:1	1	Yes	Yes	Mississippi
							Yes	Yes	Missouri
						0	Yes	Yes	Montana
1000	[illegible]3	6-10	500-600	1.0-1.3	3:1	20	No	Yes	Nebraska
1000	55	5	400	1.0	3:1	2	Yes	Yes	Nevada
1000	68	2-6	500	1.04	2.93:1	1	Yes	No	New Hampshire
1000	60	8	400	1.2	3:1	9	Yes	-[d]	New Jersey
1000	59	6	700	1.42	2.9:1	2	Yes	No	New Mexico
400 1000	75	6-8	475	.6-.8	4:1	40	Yes	No	N. Carolina
1000		7-10	700	.6	4:1	2	Yes	No	N. Dakota
1000	65	4	400	1.2	3:1	3	Yes	Yes	Ohio
1000	63	6	600	1.2	4:1	1	Yes	Yes	Oklahoma
400 1000	63	2-8		1-2	3:1	8	Yes	Yes	Oregon
1000	60	3-6	350	1.6	3.5:1	3	Yes	Yes	Pennsylvania
1000	72	6	700	.835	3:1	6	Yes	Yes	Rhode Island
						0	No	No	S. Carolina
1000	65-85	10		.8-1.2[f]	6:1 3.6:1	7	Yes	No	S. Dakota
1000	62.5	6	600	0.6[f]	4:1	1	Yes	Yes	Tennessee
1000	45	6-15	600			31	Yes	-[g]	Texas
							No	No	Utah
						0	Yes	-[h]	Vermont
						0	Yes	No	Virginia
1000	64	3	400	1.5-1.6	3:1	3	Yes	Yes	Washington
400 1000		4-8		.8-1.1	4:1	8	No	No	W. Virginia
1000		3-6	5-600	1.5	2.5:1	1	Yes	Yes	Wisconsin
1000	70	8	550	3.5	3:1	1	Yes	Yes	Wyoming
						0	Yes	Yes	District of Columbia

lusively since 1949. [e]Init. horiz. fc. [f]Avg. maint. fc .8-1.2. [g]Completed. [h]No such poles are owned by utility.

Section III

NARRATIVE RESPONSES TO QUESTIONS 10, 13, 15, 16

FIXED HIGHWAY LIGHTING QUESTIONNAIRE

QUESTION 10

How do you take glare into consideration in your highway lighting designs?

Alabama - By selection of luminaire distribution and mounting height.

Alaska - Restrict usage to IES type III Medium semi-cutoff distribution with minimum 30' mounting height.

Arizona - By placement of poles in relation to Geometrics so as to restrict blare to a minimum. Also through the use of shields.

Arkansas - Glare is not considered quantitatively; however, we rely upon experience to avoid any undesirable situations regarding the problem.

California - We use glare shields in dark areas.

Colorado - Use higher mounting height.

Connecticut - Glare is considered during design by luminaire selection which is dictated by the classification of luminaire light distributions.

Delaware - Most designs aim at minimization of direct glare affecting drivers. In high level systems being planned, an attempt is made to minimize glare for adjacent residences also.

Florida - By increasing mounting height.

Georgia - Higher mounting heights help prevent glare. Also, do not use long-non-cutoff distribution.

Hawaii - No particular consideration except that 30 ft. mounting height is used for 250 watt and 400 watt mercury vapor lights and up to 45' mounting height is used for 700 watt and 1000 watt luminaires.

Idaho - General type considerations only.

Illinois - Height and Vertical Light Control.

Indiana - Rule of Thumb Mounting Height.

Iowa - By using cutoff or semi-cutoff luminaires with either short or median distribution.

Kansas - Decrease the light intensity on approach to lighting project. (Necessary on 30' mounting height) 40" MTGH and 400 watt mercury-vapor glare is no noticeable problem.

Kentucky - No

Louisiana - The luminaire is placed over edge of pavement to reduce glare.

Maine - Using higher mounting heights. Remove luminaire from direct line of sight, e.g. locate luminaire off travelled way.

Question 10, cont'd.

Maryland - In low level lighting by shielding the luminaire(s) and/or by increasing height of the pole(s).

Michigan - Cut off distribution, cut off angle, mounting height and offset distance from edge of pavement.

Minnesota - Vertical F.C. are thought to be important in visibility, therefore a compromise in cutoff is necessary. If 5:1 spacings are not exceeded, units with better cutoff are sought.

Mississippi - In the specifications for highway luminaires and their placement along the roadways.

Missouri - Experience indicates that the 45 foot mounting height with 700w Mercury Vapor has produced satisfactory illumination without glare.

Montana - We do not normally consider glare in design. If it appears as a problem we install glare shields. We have gone to 40 feet and over mounting heights to help reduce glare.

Nebraska - By careful choice of most appropriate mounting heights and proper lamp sizes; also by using cutoff and semi-cutoff fixtures and by limiting angle of maximum candlepower on high mast fixtures.

Nevada - The glare is controlled by mounting height and IES type distribution.

New Hampshire- By using as high a mounting height as practicable and by using semi-cutoff fixtures.

New Jersey - Luminaires and new design standards are field tested before being adopted for field use. No field measurements are taken unless from observation it appears that glare is objectionable.

New Mexico - Have found a semi-cutoff fixture satisfactory. Use a 40' or higher mounting height.

North Carolina - Glare is considered in layout although not a quantitative approach.

North Dakota - Try not to install standards in locations where this may present a problem. Use 50' mounting heights.

Ohio - By use of medium cutoff distributions as well as specified minimum mounting heights based on lamp size.

Oklahoma - Fixture selection.

Oregon - Placement of light sources as far from the driver's line of vision as possible.

Pennsylvania- By proper selection of vertical light distribution consistent with mounting height.

Rhode Island- By raising light source or by setting lights farther back from the road. (There are many ways to cut down glare.)

South Carolina - Vertical height of fixtures.

South Dakota- We try to keep the mounting heights as high as practical and use only luminaires having a cutoff giving a max beam angle of approximately 65 degrees.

Tennessee - Avoid situations where it might present a problem and install glare shields where it is a problem.

Texas - We strive to reduce glare to a nominal amount by increased mounting heights and careful placement of luminaires in relation to movement of traffic.

Utah - At mounting heights of 40 to 45 feet, glare is not considered to be a problem. In exceptional cases, luminaires are shrouded.

Vermont - Consideration given to luminaire size, location and mounting height.

Virginia - Mounting height.

Washington - Selected locations are treated with glare shields.

West Virginia - Yes, usually with higher mounting heights, shields, short distribution.

Wisconsin - Using semi-cutoff and cutoff luminaires and increasing mounting heights.

Wyoming - Smaller wattage lamp and higher mounting heights.

District of Columbia - Maintaining adequate mounting heights for each type of luminaire.

QUESTION 13

a.) If you have recently completed or are now completing any new lighting installations incorporating novel or experimental features, please describe.

b.) If there is written material available from your office regarding this installation, please indicate how copies may be obtained.

Alabama - None

Question 13, cont'd:

Alaska - a.) Just completed rail-light project on major structure. Roadway is 32' wide with sidewalk on one side. Rail-light is opposite sidewalk and extends down the approach roadway which is on fill. Also, we are installing our first overhead illuminated sign utilizing HPS for an illumination source.

b.) N.A.

Colorado - None

Georgia - a.) None

b.) None

Hawaii - a.) None

b.) None

Illinois - a.) Attached a reprint concerning low pressure sodium installation in Chicago area.

Indiana - a.) A 15.5 mile system on I-80 from the Illinois State line to the toll road interchange. 3-12' lanes each way, 36' median, 11 interchanges, 800 units 400 watt high pressure sodium, 150 sign lighting units, 175 watt mercury vapor deluxe white, 45' mounting height, 10' from traveled road edge, 0.9 ftc maintained, 70% factor (maintenance), 3/1 uniformity.

Iowa - a.) No

Kansas - a.) 50' mounting height in the median using 1,000 watt mercury and 400 watt metal halide.

b.) None to date.

Louisiana - a.) No

b.) No

Maine - None

Maryland - a.) We recognize that others are doing likewise, however, we are currently in process of installing 350 high mast lighting poles (90' - 115') on a 33 mile Interstate Route. Also, a quantity of inrail eye-level lighting has been placed atop the median parapet within a two mile bridge.

b.) There are only Contract Drawings and Special Provisions available which may be obtained through this office.

Question 13, cont'd:

Michigan - a.) We have recently completed high level tower lighting for a four level interchange north of Detroit. This is the first of a number of installations of this type of lighting.

Minnesota - a.) 7-mile median mounted 400 watt HPS using Holophane 1100 series - Type I Refractor - with 8-inch light center setting. 240-270' pole spacings. 50 foot Mounting Height. Twin units - 12 feet back to back.

b.) To be completed by late 1973. Anticipate:

260' x 52 Design area :
- 1.6 initial average intensity
- 3:1 uniformity ave/min
- 6:1 max./min.
- 0.6 min @ Hur-230', T=52'
- glare acceptable

Mississippi - a.) None

Missouri - a.) Airport runway inset light fixtures with red lens are being placed across ramp terminals on an experimental basis to create a red barrier effect to prevent wrong way movements. Fixture utilizes a 45 watt center line marker light with a quartz iodine lamp. Electrical power requirements are 6.8 volts @ 6.6 amperes. Centerline spacing is 33" C.T.C. across the ramp.

b.) None available.

Montana - a.) None

b.) None

Nebraska - a.) Presently designing an intersection lighting system using 80 foot wooden pole with 4-1000 watt multi-vapor fixtures. First time in Nebraska this has been tried outside of Interstate system. Evaluation of both lighting effectiveness and economics will probably be undertaken.

Nevada - a.) None up to the present.

b.) None

New Jersey - The Route 87 Bridge in Absecon, a 2300 ft. length structure is being provided with low level rail lighting. Each fixture is 11 feet in length and contains two F 64 T-6 slim-line fluorescent lamps. The total dark space between the fixtures will be a maximum of 3 inches. The lamps will operate at 200 milliampere. To reduce costs, one 11 ft. length module is used on all spans of the structure. Provisions are incorporated in the mounting arrangement of the rail for expansion to permit straddling of expansion joints between spans. The mounting arrangement also permits considerable anchor bolt tolerance.

Question 13, cont'd:

New Mexico - a.) None

Ohio - a.) None

Oregon - a.) Flush mounting indoor type luminaire (G.E. Low Mount) in the underside of overcrossing structures for supplemental illumination and the same type luminaire in tunnel illumination.

Pennsylvania- a.) We are presently designing a tunnel lighting system for the covered section of I-95 in Philadelphia using the new IES design standard of 500 fc (daytime) in the entrance area and utilizing Low Pressure Sodium lamps.

b.) None

Rhode Island- a.) No

b.) No

South Carolina - a.) No

South Dakota- a.) We have currently under contract the installation of two 80 ft. poles with 400 watt HPS Type III luminaires (2 on one and 3 on the other) at a T at grade intersection of two major highways (Aberdeen, South Dakota). We currently have two 80 ft. poles each with three 1000 Metal Halide Type V luminaires installed and operating at an intersection of two major highways (Rapid City, South Dakota). Both installations are located within urban areas.

b.) The only written information available would be the construction plans. These plans can be obtained from the South Dakota Department of Highways.

Tennessee - a.) High Mast Installation (150' poles) I-65 and I-440 directional interchange, Davidson Company.

Vermont - a.) None

Virginia - a.) Not applicable

b.) Not applicable

Washington - a.) Twin mast arm lighting standards are mounted on the top of New Jersey type curb. We are now completing about 15 miles of continuous illumination on I-5 with this method of contruction. It provides better light and has proved safer than conventional lighting methods.

b.) No papers, as yet, have been prepared.

Question 13 cont'd:

West Virginia – a.) We are working on a system of 400 H.P.S. at 40' in Holophane 9" assymmetric fixtures, back to back on a median barrier.

Wyoming a.) No

b.) No

District of Columbia – a.) None

b.) None

QUESTION 15

What are some of the major problems you encounter in the area of fixed highway lighting for which you feel potential solutions can be obtained through appropriate research?

Alabama – None

Alaska – Better uniformity with regard to luminance as opposed to illumination. Present practice still produces dark spots which can "hide" persons and objects from the motorist. This is particularly true at low (0.6-1.5 f.c.) levels.

Arizona – High mast (100' +) lighting apparently will offer many advantages in good lighting - uniformity, general "see-ability" and economics. Good light sources are available, but more control thru optics, aiming, tilting, refraction, shielding and cutoff/s needs to be obtained.

California – We need better means of lighting areas of merging or diverging traffic.

Florida – Correct the cycling characteristic of some high pressure sodium luminaires.

Georgia – There seems to be a problem in the new designs trying to locate the lighting standard as far from the traveled roadway as possible and still have them breakaway. The higher mounting heights along with the long bracket arms produce a problem (functionally and economically) when trying to make them breakaway.

Hawaii – Development of lighting warrants for roadways other than freeways.

Question 15, cont'd:

Idaho - Primary problems relate not to the physical installations but to justification for illumination projects. More data needs to be developed on a before-and-after basis to indicate the effectiveness of illumination on such items as safety and capacity for various highway designs and environs.

Illinois - Known fog and smog areas.

Iowa - We have experienced considerable opposition to using HPS lamps from the utility companies. They feel the lamps are unproven and the public is not ready to accept them. We feel HPS offers great advantages in reducing power costs and consumption but still providing lighting that fulfills the requirements of the motorist.

Kansas - (a) Warrant other than traffic data;(b) Directional Lighting; (c) Sign Lighting; (d) Better uniformity.

Louisiana - (1) Vibration of Luminaires on Structure; (2) Lightning damage of ballasts.

Maine - (1) Reduction of glare by use of improved luminaire design; (2) Use of maximum/minimum uniformity ratios instead of average/minimum ratios.

Maryland - Overall need for lighting under varying roadway and traffic conditions and characteristics.

Michigan - There are several areas: 1. A determination of the safety and other operational aspects of using light poles in the median either on GM concrete barriers or with some other type of median barrier. 2. Development of a system of determining cable fault before digging on multiple lighting circuits. 3. Development of a system of lighting which would not be subject to knock downs or require protection.

Minnesota - Luminaire manufacturers do not keep abreast of lamp developments.

Mississippi - On our first conventional installation using 400 and 275 watt high pressure sodium mounted 50 and 30 feet, we have had a very high failure rate of ballast and have not found a solution. More research is needed in developing a more reliable ballast.

Missouri - We feel that adequate justification for warranting lighting is not available. The AASHO Informational Guide says, "A statement of design policy or guides regarding highway lighting cannot be made on a definite or positive basis for all features." Research that would provide warranting criteria based on proven need would be helpful.

Question 15 cont'd:

Montana - None

Nebraska - Use of median placed high mast poles with appropriate impact protection. Problem is getting FHWA approval for federally funded projects. We think this has promise.

Nevada - We find one major problem, encountered by fixed highway lighting, is the glare. If some research was done, such as experiments with semi-directional lighting, we feel that this could reduce the objectional glare in the line of the driver's vision and increase the vertical illumination on objects. An example would be a depressed freeway with light standards in the median behind a double barrier rail; then the light could be aimed in the direction of the traffic flow and toward outside shoulder at 7° to 10° rt. of the ahead line. The house side would illuminate the lt. shoulder under luminaires at the median. The twist angle of the luminaire on the arm could be from 45° to $60^{\circ}\pm$. Lower than 30 to 35' and a spot type light projection.

New Jersey - Excessive deterioration of luminaire reflectors in industrial areas. Perhaps some economical alternate to the present Alzak reflector could be obtained through appropriate research. Objectionable spill light in urban areas -- Redesign of luminaires could possibly eliminate some of the difficulties which are presently experienced with conventional luminaires. Present design standards are not appropriate for establishing quality designs. Average intensity of illumination and uniformity ratio are not good design standards. Perhaps average and minimum to maximum ratio may be a better way of describing and establishing design criteria. Lack of public knowledge about highway illumination -- The general public believes that highway lighting is a panacea for all nighttime highway problems. They expect white-way lighting even on remote, low traffic volume, rural intersections.

New Mexico - None

North Carolina - More study is needed to determine when median lighting is more desirable than roadside lighting; taking into account construction and maintenance costs, accident rates, median widths, speeds, volumes and the potential of secondary collisions between vehicles and downed poles. Also when breakaway poles desirable in medians.

North Dakota- There is a need to develop improved cutoff visors or shields for MV luminaires for control of street side lighting.

Question 15 cont'd:

<u>Ohio</u> - 1. Development of a cost effectiveness system for determining lighting warrants and optimum system design.
2. Effectiveness of lighting in wet weather.
3. Specifications explicit enough to control quality but not so detailed that the materials are unavailable by the time a project is constructed.

<u>Oklahoma</u> - (1) Damage to direct burial cables by pocket gophers.
(2) Failure of mast arms, luminaires and lamp damage as a result of vibration of poles mounted on bridge parapets.

<u>Oregon</u> - At the present time there are no conventional roadway lighting type luminaires designed for freeway applications.

<u>Pennsylvania</u>- (1) The calculation of horizontal footcandles on the road surface using the point-by-point method for high mast lighting. (2) Providing breakaway features for poles of 40' - 45' M.H. w/arm lengths of 25' - 30' due to the little that is known of how a pole of this mass will react if broken free of its mounting.

<u>Rhode Island</u>- Our major problem concerns knocked down poles. It is impossible to replace them as fast as they are knocked down.

<u>Tennessee</u> - A need for greater flexibility in placing standards through development of better safety devices.

<u>Texas</u> - The major problem in our high mast design is the fact that only one floodlight is presently available which combines a fairly good light distribution with a physical shape readily adaptable to a high mast environment.

<u>Utah</u> - Largest problem encountered is where state furnishes cost of material and prepares plan on lighting projects on state roads within the municipalities. The cost of installation is assumed by the local authorities and in many cases the officials are against the break away bases because of high cost of installation.

<u>Virginia</u> - Not any that couldn't be secured through better spacing, distribution, mounting heights, glare, etc.

<u>Washington</u> - 1. A good vibration damper is needed for light standards supporting post-top luminaires. This year we had 3 aluminum pole breaks due to fatigue caused by vibration.
2. Electrical disconnects are needed to augment slip bases to remove the electrical hazard at accident sites.

<u>West Virginia</u> - Our only real problem is an occasional hard-to-read photometric curve.

<u>Wyoming</u> - None at this time

<u>District of Columbia</u> - None

QUESTION 16

What specific highway lighting research projects would you recommend be encouraged by the Highway Research Board?

Alabama - None

Alaska - Optimum lighting warrants and levels. With existing high energy costs and scarcity of highway funds a modification of IES "ideals" is needed. Where is optimum level? What is optimum uniformity? Optimum being described in terms of collision costs, etc.

Arizona - XENON LIGHT SOURCE - I understand that the Xenon Light Source offers extremely good illumination, color rendition and a high watt to lumen ratio. Yet its best known usage in the U.S.A. has been with N.A.S.A. If such a good light source is available why isn't more research directed in this area instead of on the various sodium lights which apparently never will provide proper color rendition?

California - Develop a lighting fixture specifically for highway lighting (not street lighting or parking lot lighting).

Colorado - Economic comparison of lighting installation using different lamp types including low pressure sodium.

Georgia - There seems to be a problem in the new designs trying to locate the lighting standard as far from the traveled roadway as possible and still have them breakaway. The higher mounting heights along with the long bracket arms produce a problem (functionally and economically) when trying to make them breakaway.

Hawaii - Improvements in tunnel lighting methods.

Idaho - Research to assist in solving the illumination justification problem.

Illinois - Development of relation between lumination, glare and driveability.

Indiana - What light levels are required to provide adequate sight for the older eye? The age of 50 is suggested as a cutoff. What percent of nighttime travel does this age and above accomplish? Should we be establishing seeing conditions for this group rather than the younger driver?

Iowa - 1. The development of criteria for placement of high mast lighting, recommend lighting levels, uniformity, and applications to areas other than the interchange lighting (i.e., medians, intersections, etc.).

Kansas - Lowering devices for high-mast lighting (more quality needed in the latching and lowering devices for high-mast lighting).

Maine - (1) Reduction of glare by use of improved luminaire design. (2) Use of maximum/minimum uniformity ratios instead of average/minimum ratios.

Maryland - Development of warrants for lighting, specifically for rural as well as urban areas.

Mighigan - 1. Determination of the amount of light required to perform the driving task. 2. Investigation of the effect of glare on the driving task. 3. Determination of methods to provide daytime eye adaptation transition zones at entrances to tunnels and long overpasses. 4. Determination of the optimum location of signing. 5. Determination of the need for transition lighting at each end of lighted highway. 6. Research to determine the optimum light source for maximum efficiency and all weather vision. 7. Test to determine actual isolux lines on various arrangements and mounting heights of asymmetric type high mast luminaires compared with theoretical one offered by manufacturers; elliptical patterns of varying axes.

Minnesota - Sign Lighting.

Missouri - We feel that adequate justification for warranting lighting is not available. The AASHO Informational Guide says "A statement of design policy or guides regarding highway lighting cannot be made on a definite or positive basis for all features." Research that would provide warranting criteria based on proven need would be helpful.

Montana - Glare.

Nebraska - Use of high pressure sodium lamps extensively in highway lighting rather than just at railroad grade crossings.

Nevada - We find one major problem, encountered by fixed highway lighting, is the glare. If some research was done, such as experiments with semi-directional lighting, we feel that this could reduce the objectional glare in the line of the driver's vision and increase the vertical illumination on objects. An example would be depressed freeway with light standards in the median behind a double barrier rail; then the light could be aimed in the direction of the traffic flow and toward outside shoulder at 7° to 10° rt. of the ahead line. The house side would illuminate the lt. shoulder under luminaires at the median. The twist angle of the luminaire on the arm could be from 45° to 60°±. Lower than 30 to 35' and a spot type light projection.

New Jersey - Establish new design criteria -- eliminate present uniformity ratio definition. Control of spill lights.

New Mexico - None

Question 16, cont'd:

North Carolina - More study is needed to determine when median lighting is more desirable than roadside lighting; taking into account construction and maintenance costs, accident rates, median widths, speeds, volumes and the potential of secondary collisions between vehicles and downed poles. Also when are breakaway poles desirable in medians?

Ohio - 1. Field investigation of interaction of fixed lighting systems and vehicular headlights, including feasibility of fixed lighting system designed for use without headlights. 2. Determination of minimum maintained illumination level which would still provide safe movement of traffic at night. 3. Evaluation of high mast and other novel lighting systems.

Oklahoma - (1) Find method to predict pole vibration and design pole assembly to withstand these vibrations.
(2) Find a simple test method for field evaluation of highway luminaires photometrics.

Oregon - (a) Lighter colored asphalts for nighttime visibility.
(b) Economic advantage to high mast illumination.
(c) Disposal of gaseous discharge lamps.
(d) Accident/Illumination comparison involving high mast installations.

Pennsylvania- (1) A program to determine a method of calculating horizontal foot-candles in a total interchange area, using the utilized lumens method, that would correlate in some manner to the horizontal foot-candles on the road surface. (2) Research should be performed to test the frangibility, performance, and safety of steel and aluminum poles with 40' - 45 M.H. and arm lengths of 25' - 30', mounted on suitable cast aluminum transformer bases, when struck by vehicles ranging in weight between 2000 and 5000 pounds at speeds ranging between 20 and 70 m.p.h.

Rhode Island- Further investigation into high mast lighting is recommended.

South Carolina - Separate Interchange lighting - warrants and types.

Tennessee - Standardizing manufacturers to some extent to assure an installation complying with design.

Vermont - Establish a relationship between average maintained horizontal footcandles needed on the road to lighting or lack of lighting adjacent to the roadway.

Question 16, cont'd:

Washington - Condition #1: Electricity costs about 12¢ a KWH generated in a car and is used in a lamp that produces 15 to 20 lumens per watt.
Condition #2: Electricity costs 1.2¢ a KWH commercially and can be used in a luminaire producing 100 lumens per watt.
Proposition: There is an equation in terms of vehicles per lane per hour of darkness whereby it is cheaper to light the highway with fixed source lighting. Obviously, this would be safer--no oncoming headlamps. Research Project: Develop the equation.

West Virginia - None

Wisconsin - None

Wyoming - None at this time

District of Columbia - None

Section IV

QUESTIONNAIRE

NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY OF SCIENCES   NATIONAL ACADEMY OF ENGINEERING

WASHINGTON, D. C.

HIGHWAY RESEARCH BOARD
OF THE DIVISION OF ENGINEERING

December 5, 1972

The enclosed questionnaire has been designed by the Highway Research Board Committee on Visibility as a means of obtaining the latest information from the States about the design and operation of their fixed source lighting systems. This data is needed in the Committee's effort to focus attention on current and projected design practices, and upon areas needing research attention.

It is possible that the summarized data will be suitable for publication in Circular form, but in any case you will be given the summary of replies. This should prove helpful to you in permitting an assessment of your design and operating practices versus those in other states. The data could, of course, point the way toward more uniform and therefore less costly and more effective designs.

You may need to pass the questionnaire on to others for completion; please feel free to do so, including both design and operations agencies where these are separated.

I hope that the completed questionnaire will be returned to Mr. Lau on or before the February 1, 1973 deadline. Thanks for your help.

Very truly yours,

W. N. Carey, Jr.
Executive Director

Enclosure

MAIL ADDRESS: 2101 CONSTITUTION AVE., WASHINGTON, D.C. 20418 OFFICE ADDRESS: 2100 PENNSYLVANIA AVE., N.W.

HIGHWAY RESEARCH BOARD, COMMITTEE A3A04 - VISIBILITY

FIXED HIGHWAY LIGHTING QUESTIONNAIRE

After completion, and prior to February 1, 1973, please return this questionnaire to:

Mr. Ralph R. Lau
Electrical Engineer
Bureau of Design
Pennsylvania Dept. of Transportation
Harrisburg, Pennsylvania 17120

He is Chairman of the Ad Hoc Committee responsible for analysis of the replies.

STATE ______________________________ DATE ____________

RESPONDENTS ____________________________________ TITLE __________________________

____________________________________ __________________________

1. Describe a typical new highway lighting system designed and installed by your State Highway Department or Department of Transportation.

		MAINLINE		RAMP		CROSSROAD	
		a. Conven-tional	b. Hi-Mast	c. Conven-tional	d. Hi-Mast	e. Conven-tional	f. Hi-Mast
Lamp and Wattage	MV						
	*MULTI V						
	HPS						
	OTHER						
Mounting Height							
Avg. Maint. fc Design Level							
Max. Uniformity Ratio (Avg./Min.)							
g. Power Supply Voltage	/_/ 120/240		/_/ 120/208		/_/ 240/480		/_/ 277/480

*Metal Halides

2. What type of light source do you favor for future use in highway lighting? (Number in order of preference)

- /_/ Mercury Vapor
- /_/ Multi Vapor
- /_/ Fluorescent
- /_/ High Pressure Sodium
- /_/ Low Pressure Sodium
- /_/ Other - describe

3. What type of light source do you use for sign lighting? (Number in order of predominance)

Present Use		Future Use
/_/	Mercury Vapor	/_/
/_/	Fluorescent	/_/
/_/	Multi Vapor	/_/
/_/	Other	/_/

4. Who is responsible for the highway lighting design work in your State?

- /__/ In-house staff
  - /__/ Illumination Engineer
  - /__/ Electrical Engineer
  - /__/ Traffic Engineer
  - /__/ Other ______________________
- /__/ Consultant Firm
- /__/ Utility Company
- /__/ Other

5. Who owns a completed highway lighting system after it has been installed by the State?

Route	State	County or Municipality	Utility Company
Interstate			
Other			

6. Indicate the percentage of the installation cost and the annual energy and maintenance costs paid by the county or municipality and by the State for a highway lighting system installed by the State.

Route	Function	County or Municipality	State
Interstate	Installation		
	Energy		
	Maintenance		
Other	Installation		
	Energy		
	Maintenance		

7. A. Who is responsible for normal highway lighting maintenance for a system which has been installed by the State on an Interstate Route?

- /_/ State
- /_/ County
- /_/ Municipality
- /_/ Utility Company
- /_/ Other ____________________

B. Who is responsible for normal highway lighting maintenance for a system which has been installed by the State on other than an Interstate Route?

- /_/ State
- /_/ County
- /_/ Municipality
- /_/ Utility Company
- /_/ Other ____________________

In 7A and 7B above, please briefly explain unusual shared or conditional responsibilities, if any.

8. At what intervals are the luminaires cleaned and group relamped on a highway lighting system which has been installed by the State?

Cleaned every ______________________________

Relamped every ______________________ (Merc.)

______________________ (Multi V - Metal Halides)

______________________ (HPS)

9. What is your highway lighting design primarily based on?

/ / Average maintained horizontal fc.

/ / Average maintained vertical fc.

/ / Uniformity ratio

/ / Luminance

/ / Glare

/ / Other

10. How do you take glare into consideration in your highway lighting designs?

____

____

____

____

11. Approximately what is the energy cost per Kilowatt-Hour for your highway lighting systems?

____________________ cents per KWH

12. If you have had experience with high mast lighting installations (e.g., 80 ft. or higher) in your State, please furnish the following information:

Type of Support	/__/ Tower /__/ Pole
Height	____________________ ft.
Type Lamp	____________________
Lamp Wattage	____________________ watts
Max. CP Angle	____________________ °
Luminaires Per Tower	____________________
Avg. Tower Spacing	____________________ ft.
Avg. Initial fc.	____________________ fc.
Uniformity Ratio	____________ :1 ______
No. of Hi-Mast Installations	____________________

General Comments: ______________________________

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13. If you have recently completed or are now completing any new lighting installations incorporating novel or experimental features, please describe: (Use extra sheets if necessary)

If there is written material available from your office regarding this installation, please indicate how copies may be obtained.

14. A. Where new lighting is installed on new poles, are all unprotected poles of the breakaway type?

YES /__/ NO /__/

B. Do you have a program to replace older unprotected and unyielding poles with the breakaway type?

YES /__/ NO /__/

15. What are some of the major problems you encounter in the area of fixed highway lighting for which you feel potential solutions can be obtained through appropriate research? (Use extra sheet if necessary)

16. What specific highway lighting research projects would you recommend be encouraged by the Highway Research Board? (Use extra sheet if necessary)

HIGHWAY RESEARCH BOARD
NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL
2101 Constitution Avenue Washington, D. C. 20418

ADDRESS CORRECTION REQUESTED

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