Approved 2-27-91
Date

MINUTES OF THE House COMMITTEE ON Transportation.

The meeting was called to order by Representative Herman G. Dillon at
Chairperson

1:33XXn./p.m. on February 20, 1991in room 519-S of the Capitol.

All members were present except:

Representative Don Rezac - Excused
Representative Jeff Freeman - Excused
Representative Mark Parkinson - Excused

Committee staff present:

Bruce Kinzie - Revisor of Statutes
Hank Avila - Legislative Research
Jo Copeland - Committee Secretary

Conferees appearing before the committee:

Representative Rick Bowden
Andrew Smith - V-President of Engineering for Emergency Lights from St. Louis, Mo.
Jim Woydziak - Fire Chief of Emporia
Keith Mendenhall
Mike Eason

Chairman Dillon called the meeting to order.

Chairman Dillon entertained a motion to approve the February 12th and February 13th minutes. Representatative McKechnie moved the motion and Representative Everhart seconded it. Motion carried.

HB 2139 and HB 2177 were passed over.

HB 2106 - Allowing use of blue lights on emergency vehicles.

Chairman Dillon introduced Representative Rick Bowden who testified in support of HB 2106. (Attachment 1)

Representative Rick Bowden introduced Andrew Smith who testified in support of HB 2106. (Attachment 2)

Questions and discussion followed.

Chairman Dillon introduced James Woydziak who testified in support of HB 2106. (Attachment 3)

Chairman Dillon introduced Keith Mendenhall who testified in support of HB 2106. He stated it would be safer for Fire Trucks and Ambulances to have blue lights. Motorists could see the blue light quicker and faster to start slowing down for emergency vehicles. Blue lights are very conspicious and the primary color for emergency lights.

Chairman Dillon introduced Mike Eason who testified in support of HB 2106. He stated the bill would give the Highway Patrol the option to keep present lighting system with just red or switch to red and blue. He supported previous testimony given.

End of hearing on HB 2106.

Chairman Dillon introduced the new Secretary of Transportation, Gary Stotts. He briefed the committee on his experience and told the committee he would provide information they needed at their request. His primary concern is the preservation of the new Highway Program.

Questions and discussion followed.

CONTINUATION SHEET

MINUTES OF THE House COMMITTEE ON Transportation,

room 519-S Statehouse, at 1:33 ~~a.m.~~/p.m. on February 20, 1991.

Representative McKechnie moved for the request of Bert Cantwells Vehicle Identification Number Bill. (VIN) Representative Gross seconded the motion. Motion carried.

Adjourned at 2:12 p.m.

GUEST LIST

COMMITTEE: HOUSE TRANSPORTATION COMMITTEE

DATE: 2-20-91

NAME (PLEASE PRINT)	ADDRESS	COMPANY/ORGANIZATION
BoB Totten	ToPeka	K-C-A
Gary Stotts	TOPEKA	KDOT
Keith Mendenhall	Plevna	Reno Co. Fire
James L. Woydziak	Emporia	Emporia Fire Dept.
Ken Stodgell	Topeka	KDOT
Lt. Bill Jacobs	TOPEKA	Ks HIGHWAY PATROL
JEFF DEGRAFFENREID	TOPEKA	KPOA
Lucille Cox	Rose Hill	Sr. Citizens Group
Kermit Cox	Rose Hill	Sr. Citizens Group
PAUL W. MATTHEWS	OKLA. CITY, OK	HIGHWAY USERS FEDERATION
Tom Whitaker	Topeka	Ks Motor Carriers Assn.

HOUSE BILL No. 2106

By Represenatives Bowden and Dean

AN ACT relating to motor vehicles; concerning lamps and lights on authorized emergency vehicles; amending K.S.A. 1990 Supp. 8-1720 and repealing the existing section.

Be it enacted by the llegislature of the State of Kansas:

Section 1. K.S.A. 1990 Supp. 8-1720 is hereby amended to read as follows: 8-1720. *(a) Except as provided in subsection (b),* every authorized emergency vehicle, in addition to any other equipment required by this act, shall be equipped with signal lights mounted as high and as widely spaced laterally as practicable, which shall be capable of displaying to the front two alternately flashing red lights located at the same level and to the rear two alternately flashing red lights located at the same level, or in lieu thereof, any such authorized emergency vehicle shall be equipped with at least one rotating or oscillating light, which shall be mounted as high as practicable on such vehicle and which shall display to the front and rear of such vehicle a flashing red light or alternate flashes of red and white lights in combination. All lights required or authorized by this subsection shall have sufficient intensity to be visible at 500 feet in normal sunlight. Every authorized emergency vehicle may, but need not~~,~~ be equipped with head lamps which alternately flash from high to low beam or simultaneously flash high to low beam.

(b) A police vehicle when used as an authorized emergency vehicle may, but need not, be equipped with:

(1) Head lamps which alternately flash from high to low beam or simutaneously flash from high to low beam; ~~or~~

(2) flashing ~~red~~ lights specified ~~herein~~ *in subsection (a)*, but any flashing lights, ~~including rotating or oscillating lights,~~ used on a police vehicle, other than the flashing lights specified in K.S.A. 8-1722, and amendments thereto, *rotating or oscillating lights* or alternately flashing head lamps or simultaneously flashing head lamps, shall be red in color; or

(3) rotating, flashing, or oscillating lights, which may display a red or red and blue light in combination.

Sec. 2. K.S.A. 1990 Supp. 8-1720 is hereby repealed.

House Transportation
2-20-91
ATTACHMENT 1

SAE DEMO
9/22 THRU 9/24/88
ANN ARBOR, MICHIGAN

Purpose of Demonstration- Flash Rate

- Evaluate effectiveness of flash rates higher than current SAE maximum flash rate of 120 fpm to 360 fpm in rotating devices.
- Do this keeping color and flash energy (per flash) equal.
- Rate these incrementally faster rates in relation to the 120 fpm standard and in relation to each other (i.e. 360 fpm vs 120 fpm and vs. 180, 240, 300) in terms of "which is a more effective (attention getting) signal".
- Determine if in this range there is an "optimum" or "most effective" flash rate.
- Determine if night viewing vs. day viewing has any impact on the results.
- Use the results of this demonstration to propose a new flash rate standard for emergency warning devices.

Purpose of Demonstration- Color

- Evaluate the effectiveness as determined by perceived "brightness" of a blue warning signal compared to a red warning signal under both daylight and nighttime viewing.
- Determine the light output level required in blue to equal the perceived brightness of a red signal of minimum SAE J845 flash energy.

House Transportation
2-20-91
ATTACHMENT 2-1

Purpose of Demonstration- Headlight Flashers

- Evaluate the effectiveness of a "pulsating" headlight flasher (headlights pulse- dim to bright- at a rate of approximately 3.5 times a second- all headlights pulse together vs. left and right side flashing alternately. The filaments never shut off they merely reduce in intensity then return to full brightness.) vs. a conventional alternating headlight flasher operating at 1.5 times a second.

Test Results- Flash Rate

- The data showed a definite correlation between perceived effectiveness and increased flash rate.

- The higher the rate above 120 fpm the greater the effectiveness as indicated by the ever increasing percentage of "more effective" votes and decreasing percentage of "less effective" and "equal" votes as the flash rate incrementaly increased above a lower flash rate of comparison.

- The data also suggests at least 50% increase in flash rate is required to "see a difference" between two different rates, i.e. 120 fpm vs. 180 fpm (50% increase) 20% of viewers rated them "equal" or "same", 120 fpm vs. 240 fpm (100% increase) only 4% of viewers rated them "equal" or "same".

- In the test group the highest (360 fpm) flash rate was the most effective as seen by the steadily higher percentage of "more effective" votes cast as the flash rate increased above 120 fpm and the higher percentage of "more effectiveness" votes cast in favor of the 360 fpm vs. 240 fpm (the number of "equal" or "same" votes increased in the 240 fpm vs. 360 fpm as compared to 120 fpm vs. 360 fpm as would be expected as discussed earlier, as the flash rates get closer to each other - 300 fpm vs. 360 fpm (20% difference) was not compared because of this.)

Test Results - Color

- The data suggests blue color light was rated as "brighter" both day and night.

- In daylight the blue light had to have approximately equal flash energy to be rated "brighter" than red. Interpolation of a plot of blue/red flash energy ratios vs. percent of observers seeing red and blue as equal suggests a ratio of .85 blue to red flash energy rates equally bright to observers in daylight.

- At nighttime a blue signal only .41 times the strength of red was rated "brighter". Extrapolating the nighttime data produces a ratio in the range of 0.2 blue to red flash energy for "equal" percieved brightness.

- These results differ from previous tests. Possible explanations are:

  The test was done in Michigan. State and local police use primarily blue warning signals. Test observers included 3-4 local policemen who use blue lights. Perhaps some local bias exists for the color blue.

  Night viewing was done first. The completed test data sheets were attached to the daytime data sheets when the daytime test was taken. Some viewers may have been biased by the night viewing data.

- The test does reinforce the significance of the color blue as a warning signal, particularly at nighttime.

Test Results - Headlight Flashers

- Of the 32 viewers 16 rated the conventional 90 fpm flasher more effective, 16 rated the 3.5 times a second (210 fpm) pulsating flasher more effective.

- This suggests the pulsating flasher is equal in effectiveness to the conventional "Wig-Wag" flasher.

Flash Rate Test
Data Regrouped by #Bulbs
Day Test

Note: 37 Observation Obs 1-8
39 Observation Obs 9-18

OBS	#Bulbs	2+ Bulb Rotator More Effective			2 Bulb Rotator More Effective			Equal		
			Ave.	%		Ave.	%		Ave.	%
3	3	29			3			5		
7	3	22			7			8		
12	3	25	25	67%	6	5	14%	8	7	19%
1	4	35			2					
5	4	36			1					
9	4	34	35	93%	1	1	4%	4	1	4%
4	5	36			1					
8	5	36			1					
11	5	37	36	96%	2	1	4%			0%
2	6	36			1					
6	6	37								
10	6	38	37	98%	1	1	2%			0%

OBS	#Bulbs	2 Bulb Rotator More Effective			6 Bulb Rotator More Effective			Equal		
			Ave.	%		Ave.	%		Ave.	%
13	2 vs 6	1			38					
16	2 vs 6	0			39					
18	2 vs 6	1	1	2%	38	38	98%			0%

OBS	#Bulbs	4 Bulb Rotator More Effective			6 Bulb Rotator More Effective			Equal		
			Ave.	%		Ave.	%		Ave.	%
14	4 vs 6	2			32			5		
15	4 vs 6	1			36			2		
17	4 vs 6	0	1	3%	35	34	38%	4	4	9%

Data Suggests:

- It requires 50+% increase in flash rate to consistantly "see a difference" between two different rates- i.e. 120 fpm vs. 180 fpm- 20% of observers rated them "equal" or "same" (50% difference) above 100% increase in flash rate- consistantly rated "more effective".

- Higher the flash rate the greater the effectiveness.

Emergency Warning Devices Subcommittee
Lighting Demonstration
Ann Arbor, Michigan September 1987

DATA SUMMARY

Test: COLOR COMPARISON [✓ FLASH RATE] "WHICH IS MORE EFFECTIVE"

Time: [✓ DAY] NIGHT

37 BALLOTS OBS. #1 → 8
39 BALLOTS OBS #9 → 18

OBS	# BULBS	DEVICE ON YOUR LEFT		DEVICE ON YOUR RIGHT	# BULBS	OBS
1	4	35		2	2	1
2	6	36		1	"	2
3	3	29	5	3	"	3
4	5	36		1	"	4
5	4	36		1	"	5
6	6	37			"	6
7	3	22	8	7	"	7
8	5	36		1	"	8
9	4	34	4	1	"	9
10	6	38		1	"	10
11	5	37	2		"	11
12	3	25	8	6	"	12
13	2	1		38	6	13
14	4	2	5	32	"	14
15	4	1	2	36	"	15
16	2			39	"	16
17	4		4	35	"	17
18	2	1		38	"	18
19		EACH DEVICE ROTATED AT EXACTLY 60 RPM				19
20		2 BULBS = 120 FLASH/MIN 6 BULBS = 360 FLASH/MIN				20

Emergency Warning Devices Subcommittee
Lighting Demonstration
Ann Arbor, Michigan September 1987

DATA Jc Ay
37 BALLOTS

Test: COLOR COMPARISON [✓ FLASH RATE] "WHICH IS MORE EFFECTIVE"

Time: DAY [✓ NIGHT]

OBS	# BULBS	DEVICE ON YOUR LEFT	"SAME"	DEVICE ON YOUR RIGHT	# BULBS	OBS
1	4	37			2	1
2	6	37			"	2
3	3	22	6	9	"	3
4	5	36		1	"	4
5	4	28	4	5	"	5
6	6	37			"	6
7	3	21	6	10	"	7
8	5	36		1	"	8
9	4	32	4	1	"	9
10	6	37			"	10
11	5	35	1	1	"	11
12	3	17	8	12	"	12
13	2	1		36	6	13
14	4	1	4	32	"	14
15	4	2	2	33	"	15
16	2			37	"	16
17	4	1	4	32	"	17
18	2	1		36	"	18
19						19
20						20

Color Test

Color	Bulb	Flash Engergy	Ratio to Red
Red	1156	61.2	1.0
Blue	1156	24.9	.41
Blue	795	70.2	1.15
Blue	H-5 100w	115.2	1.88

Day Test

OBS	Blue Brighter	Red Brighter	Equal	"Redefined" Number	Equal %	Blue/Red Ratio	Bulb
1	4	27	7	15	39	.41	1156
2	32	6	0	12	32	1.88	H-5
3	29	3	6	12	32	1.15	795
4	33	3	2	8	21	1.88	H-5
5	13	16	9	35	92	.41	1156
6	28	4	6	14	37	1.15	795
7	12	16	10	34	89	.41	1156
8	25	7	7	21	55	1.15	795
9	31	2	5	9	24	1.88	H-5
10	9	22	7	25	66	.41	1156
11	32	2	4	8	21	1.88	H-5
12	30	2	6	10	26	1.15	795

Regrouped by Bulb Type

OBS	"Redefined" Number	Equal %	Average		Blue/Red Ratio
			Number	%	
1	.15	39			
5	35	92			
7	34	89			
10	25	66	27	72%	.41
3	12	32			
6	14	37			
8	21	55			
12	10	26	14	38%	1.15
2	12	32			
4	8	21			
9	9	24			
11	8	21	9	24%	1.88

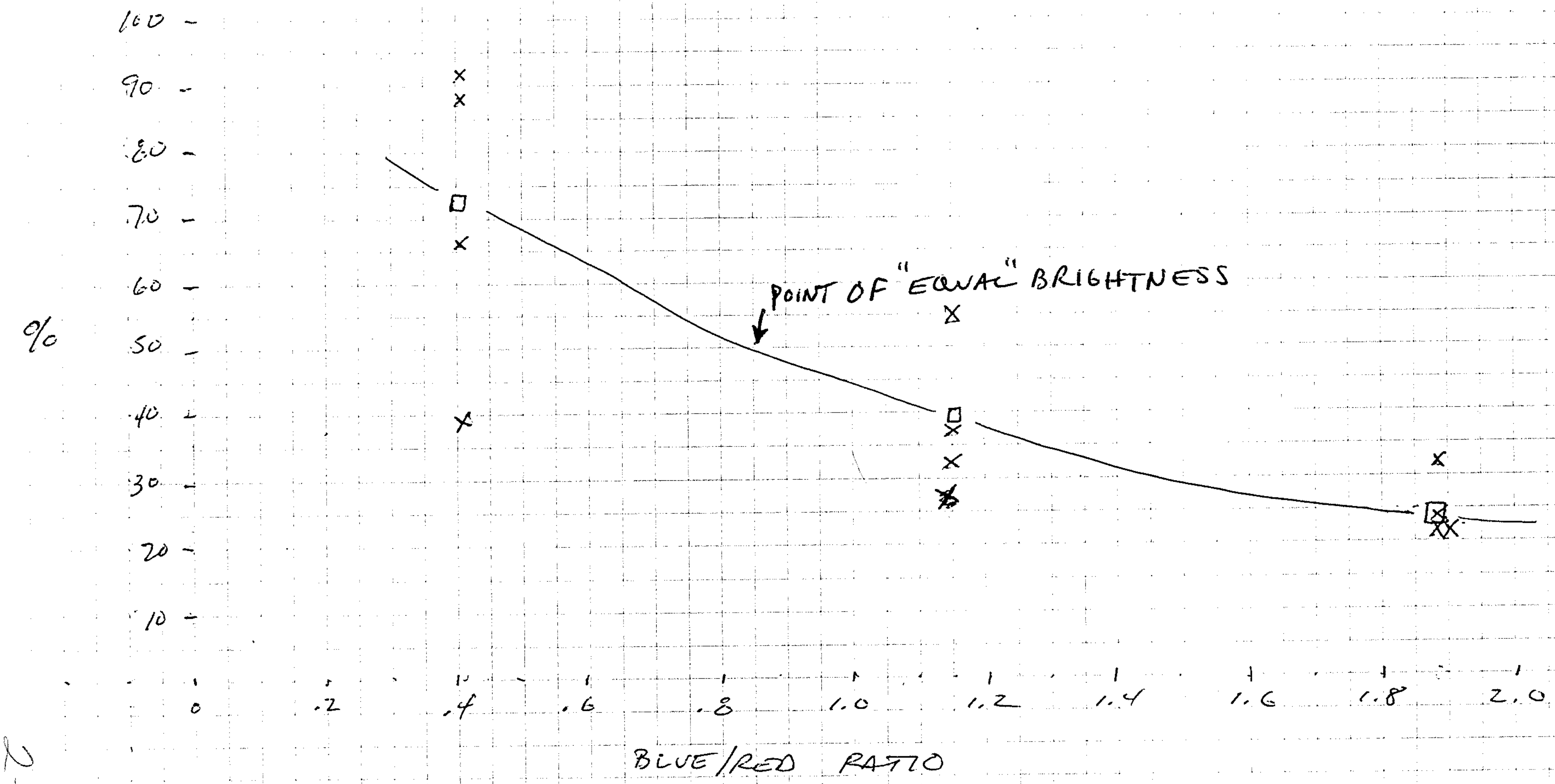
Night Test

OBS	Blue Brighter	Red Brighter	Equal	"Redefined" Number	Equal %	Blue/Red Ratio
1	34	3		6	16	.41
2	35	1		2	6	1.88
3	35	2		4	11	1.15
4	35	2		4	11	1.88
5	28	7	2	16	43	.41
6	34	2	1	5	14	1.15
7	27	9	1	19	51	.41
8	36	1		2	5	1.15
9	36	1		2	5	1.88
10	28	9		18	49	.41
11	36	1		2	5	1.88
12	33	4		8	22	1.15

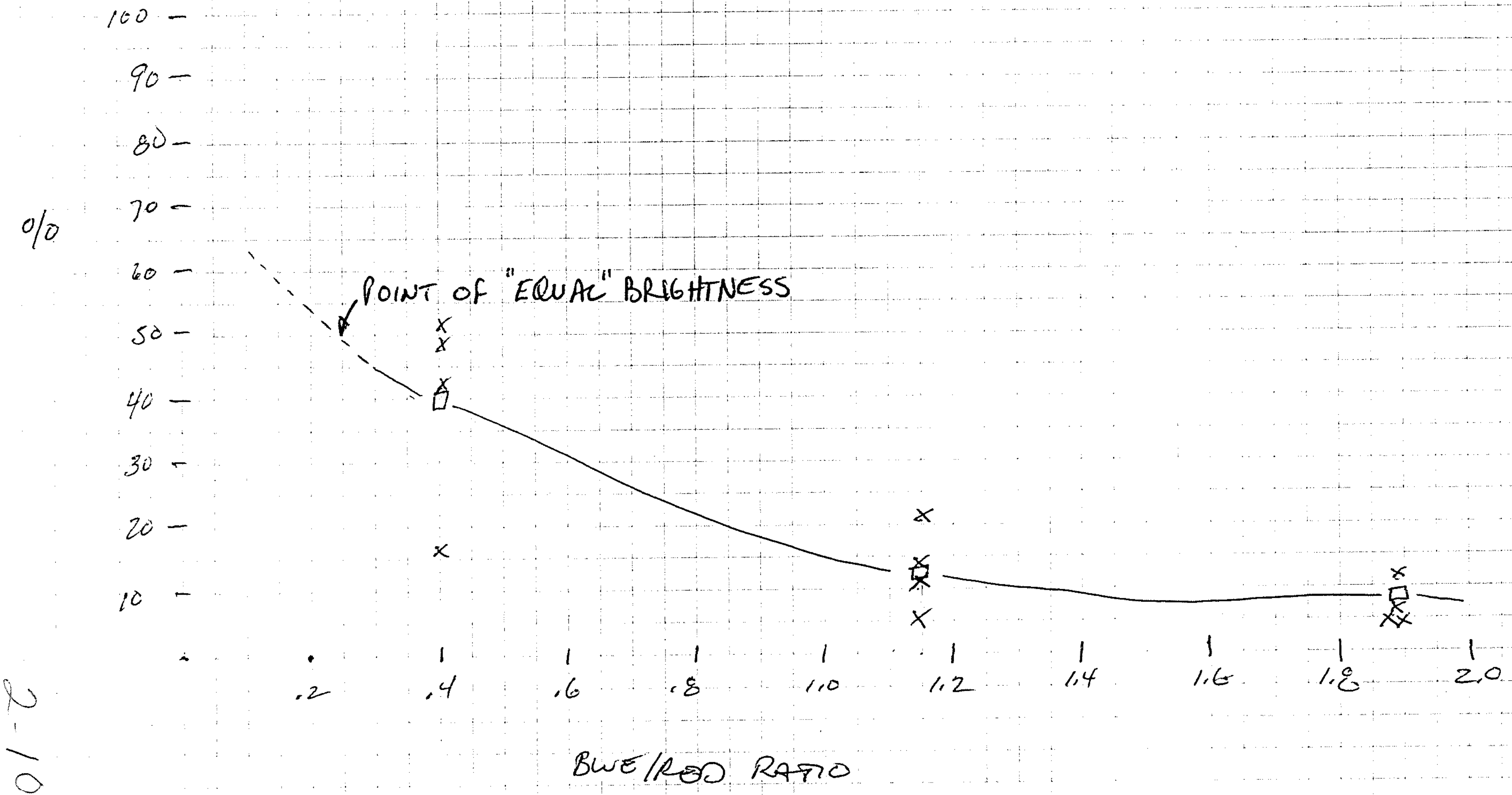
Regrouped by Bulb Type

	"Redefined"	Equal	Average		Blue/Red
OBS	Number	%	Number	%	Ratio
1	6	16			
5	16	43			
7	19	51			
10	18	49	15	40%	.41
3	4	11			
6	5	14			
8	2	5			
12	8	22	5	13%	1.15
2	2	6			
4	4	11			
9	2	5			
11	2	5	3	7%	1.88

% OF OBSERVERS SEEING RED & BLUE EQUAL - DAY



% OF OBSERVERS SEEING RED & BLUE EQUAL- NIGHT



Emergency Warning Devices Subcommittee
Lighting Demonstration
Ann Arbor, Michigan September 1987

DATA SUM 4
38 BALLOTS TOTAL

Test: [✓ COLOR COMPARISON] **Time:** [✓ DAY]

FLASH RATE AND ETM VS STD HEADLIGHT FLASHER (OBS #13) NIGHT ← "WHICH IS MORE EFFECTIVE"

← "WHICH IS BRIGHTER" → (COLOR TEST)

OBS	BWE	DEVICE ON YOUR LEFT (BWE)	"SAME"	DEVICE ON YOUR RIGHT (RED)	RED	OBS
1	1156	4	7	27	1156	1
2	H-5	32		6	"	2
3	795	29	6	3	"	3
4	H-5	33	2	3	"	4
5	1156	13	9	16	"	5
6	795	28	6	4	"	6
7	1156	12	10	16	"	7
8	795	25	7	7	"	8
9	H-5	31	5	2	"	9
10	1156	9	7	22	"	10
11	H-5	32	4	2	"	11
12	795	30	6	2	"	12
13		STD ALTERNATING FLASHER 19	0	ETM PULSATING FLASHER 19		13
14		COLOR BULB FLASH ENERGY				14
15		RED 1156 61.2cd sec				15
16		BWE 1156 24.9				16
17		BWE S-795 70.2				17
18		BWE H-5(70W) 115.2				18
19						19
20						20

STD → 90 FPM HEADLIGHT FLASHER VS. ETM 21.6 FLASH/MIN HEADLIGHT FLASHER 3.6 x SEC) - PULSATES BOTH HEADLIGHTS AT ONCE VS. ALTERNATES

Emergency Warning Devices Subcommittee
Lighting Demonstration
Ann Arbor, Michigan September 1987

DATA SU ARY
37 BALLOTS

Test: [✓ COLOR COMPARISON] FLASH RATE "WHICH IS BRIGHTER"

Time: DAY [✓ NIGHT]

OBS	BLUE	DEVICE ON YOUR LEFT	"SAME"	DEVICE ON YOUR RIGHT	RED	OBS
1	1156	34		3	1156	1
2	H-S	35 (NOTE: 1 BALLOT DID NOT RESPOND TO #2)		1	"	2
3	795	35		2	"	3
4	H-S	35		2	"	4
5	1156	28	2	7	"	5
6	795	34	1	2	"	6
7	1156	27	1	9	"	7
8	795	36		1	"	8
9	H-S	36		1	"	9
10	1156	28		9	"	10
11	H-S	36		1	"	11
12	795	33		4	"	12
13						13
14						14
15						15
16						16
17						17
18						18
19						19
20						20

COLOR	BULB	FLASH ENERGY
RED	1156	61.2 cd sec
BLUE	1156	24.9
BLUE	S795 ~~H1 (55w)~~	70.2
BLUE	H.S (100w)	115.2

7/87

W. Kenneth Menke
415 Park Avenue
Glendale, Missouri 63122

To: Members of the Emergency Warning Lights and Devices Subcommittee of the SAE

Subject: Data from the July meeting in St. Louis 7/87

I. Red/Blue Intensity

Day Test	Red Brighter	Blue Brighter	Red /Blue Equal	Intensity-Cd Sec Red	Blue	Blue/Red Ratio
1	7	0	0	54	21	.39
2	0	1	6	54	21	.39
3	6	0	1	54	64	1.19
4	6	0	1	Approx. 130	21	.16
5	3	1	3	54	93	1.72
6	7	0	0	Approx. 200	21	.11
7	7	0	0	54	21	.39
8	4	0	3	54	93	1.72
9	3	0	4	54	64	1.19
10	7	0	0	54	21	.39
11	6	0	1	54	64	1.19
12	4	0	0 (only 4 obs)	54	21	.39
13	7	0	0	54	21	.39
14	0	3	4	54	93	1.72
15	5	1	1	54	64	1.19
16	0	1	6	54	93	1.72
17	0	2	5	54	93	1.72
Night test						
1	4	2	0	54	21	.39
2	0	6	0	54	93	1.72
3	0	2	4	54	64	1.19
4	0	5	1	54	93	1.72
5	3	2	1	54	21	.39
6	0	4	2	54	93	1.72
7	0	6	0	54	64	1.19
8	0	6	0	54	64	1.19
9	2	2	2	54	21	.39
10	0	6	0	54	93	1.72
11	0	5	1	54	64	1.19
12	3	3	0	Approx. 130	21	.16
13	1	2	3	54	21	.39
14	0	5	1	54	21	.39
15	1	2	3	54	21	.39
16	3	2	1	Approx. 130	21	.16
17	0	6	0	54	93	1.72
18	0	0	4 (Only 4 obs)	54	21	.39

2-13

II. Comparison of Strobe and Rotating Beacon of same Flash Energy and color. (AND FLASH RATE(ACS))

All observers agreed that the units appeared to be equal both day and night.

III. Siren Range Demonstration

In line approach test

Siren Tone	Distance at which siren was first heard	
	Car 1	Car 2
Hi Lo	250, 300	300, 200
Yelp	350, 350	250, 225
Wail	450, 450	350, 300

Right angle Approach test

Hi Lo	100	75-100
Yelp	250	75-150
Wail	200	75-150

IV. Flash rate test

In general the higher total energy signals (higher flash rate) seemed superior to the lower total energy signal (lower flash rate) except that there seemed a point at about 300 flashes per minute where the signal lost its pattern and became a blur. This demonstration seems to need refinement before presentation to a larger population.

Miscellaneous Personal Calculations

I worked with the Red/Blue intensity data and developed the following curves. Given the small amount of data, I am not certain the correlations are valid but they certainly are interesting.

I started with the following assumption:

If equal numbers of observers think that for a given signal red is brighter than Blue and that Blue is brighter than Red, then the signals are equal. Mathematically, the number of observers reporting a pair of signals equal is the sum of the observers reporting the signal as equal plus two times the lesser of those reporting Red brighter that Blue or Blue brighter than Red.

For example, consider the following imaginary data set.

Test	Red Brighter	Blue Brighter	Red /Blue Equal
1	3	0	4
2	0	3	4
3	5	2	0
4	4	1	2
5	1	4	2
6	2	5	0

The redefined number of observers seeing equal brightness for all the above data would be **four** when calculated using the preceding formula.

Taking the actual data and calculating the redefined number of equal provides the following table.

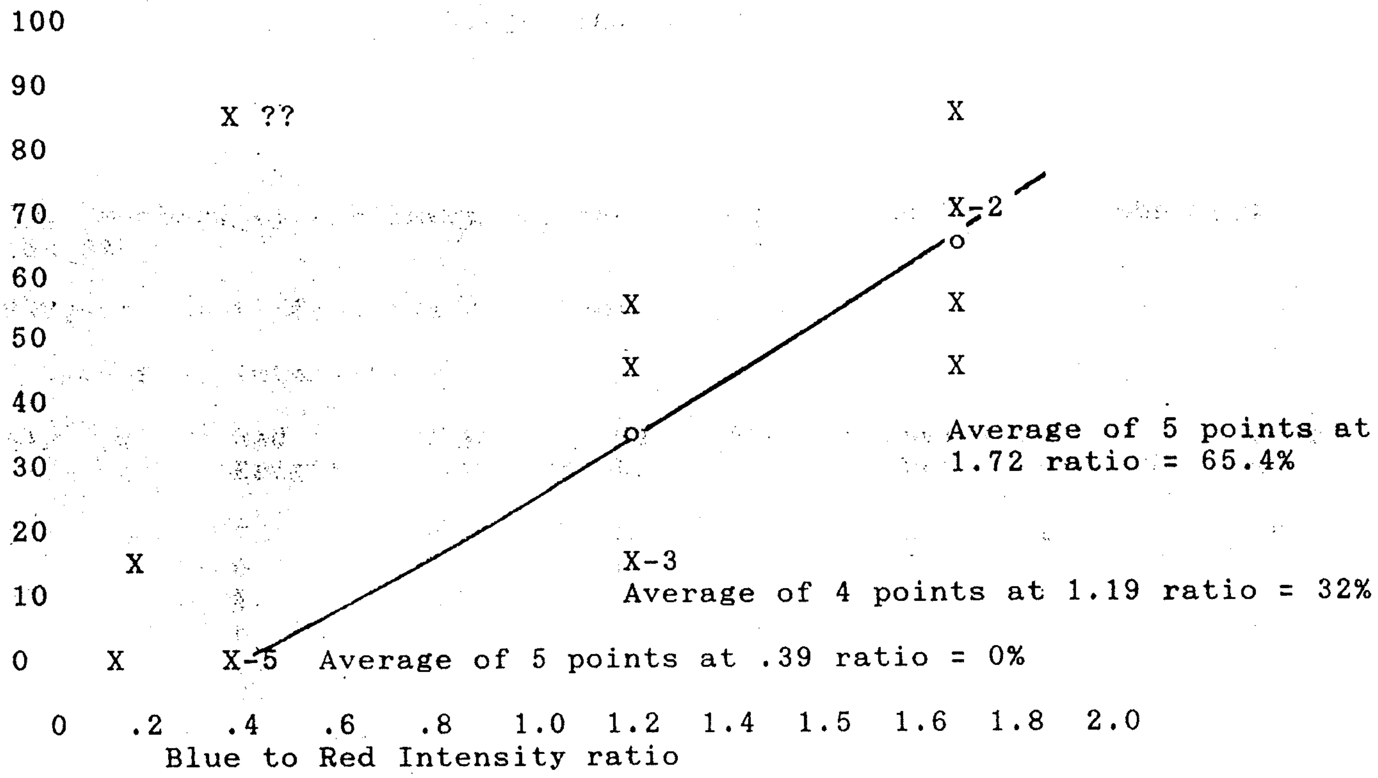
I. Red/Blue Intensity

Day Test	Red Brighter	Blue Brighter	Red /Blue Equal	Equal as Number	Redefined Percent	Blue/Red Ratio
1	7	0	0	0	0	.39
2	0	1	6	6	85	.39
3	6	0	1	1	14	1.19
4	6	0	1	1	14	.16
5	3	1	3	5	71	1.72
6	7	0	0	0	0	.11
7	7	0	0	0	0	.39
8	4	0	3	3	43	1.72
9	3	0	4	4	57	1.19
10	7	0	0	0	0	.39
11	6	0	1	1	14	1.19
12	4	0	0 (only 4 obs)	0	0	.39
13	7	0	0	0	0	.39
14	0	3	4	4	57	1.72
15	5	1	1	3	43	1.19
16	0	1	6	6	85	1.72
17	0	2	5	5	71	1.72
Night test						
1	4	2	0	4	66	.39
2	0	6	0	0	0	1.72
3	0	2	4	4	66	1.19
4	0	5	1	1	17	1.72
5	3	2	1	5	83	.39
6	0	4	2	2	33	1.72
7	0	6	0	0	0	1.19
8	0	6	0	0	0	1.19
9	2	2	2	6	100	.39
10	0	6	0	0	0	1.72
11	0	5	1	1	17	1.19
12	3	3	0	6	100	.16
13	1	2	3	5	83	.39
14	0	5	1	1	17	.39
15	1	2	3	5	83	.39
16	3	2	1	5	83	.16
17	0	6	0	0	0	1.72
18	0	0	4 (Only 4 obs)	4	100	.39

On the next page, I have plotted the percentage of observers seeing the signal as equal (redefined) as a function of the Blue/Red Intensity Ratio for each observation. I also plotted the average of all observations for each Intensity Ratio and got a fairly continuous curve.

KEY RESULT → According to these curves, 65% of the observers thought Red and Blue equal during the day when the Blue was 1.72 times more intense than the Red. At night, 76% of the observers thought Red and Blue equal when the Blue was .39 times as intense as the Red.

Percentage of Observers seeing Red and Blue Equal--Day

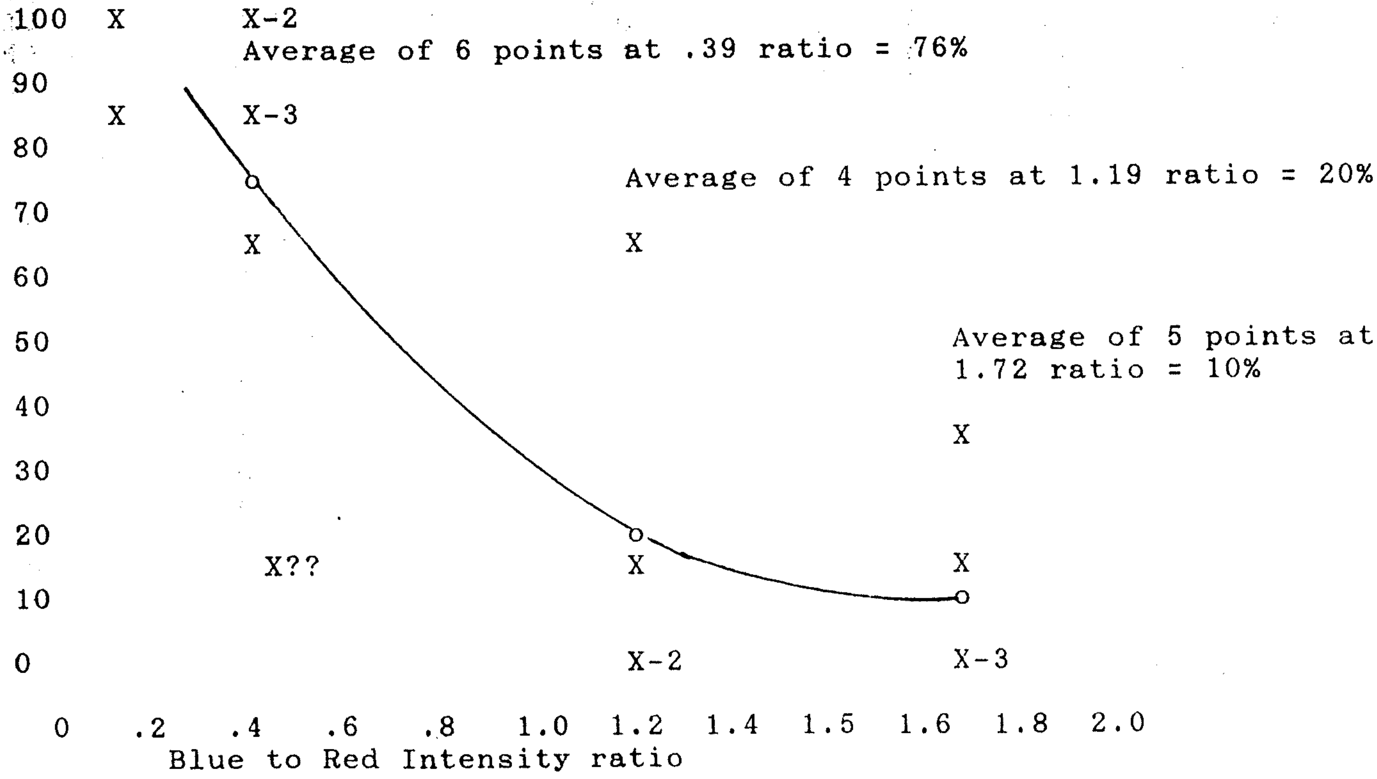


Average of 5 points at 1.72 ratio = 65.4%

Average of 4 points at 1.19 ratio = 32%

Average of 5 points at .39 ratio = 0%

Percentage of Observers seeing Red and Blue Equal--Night



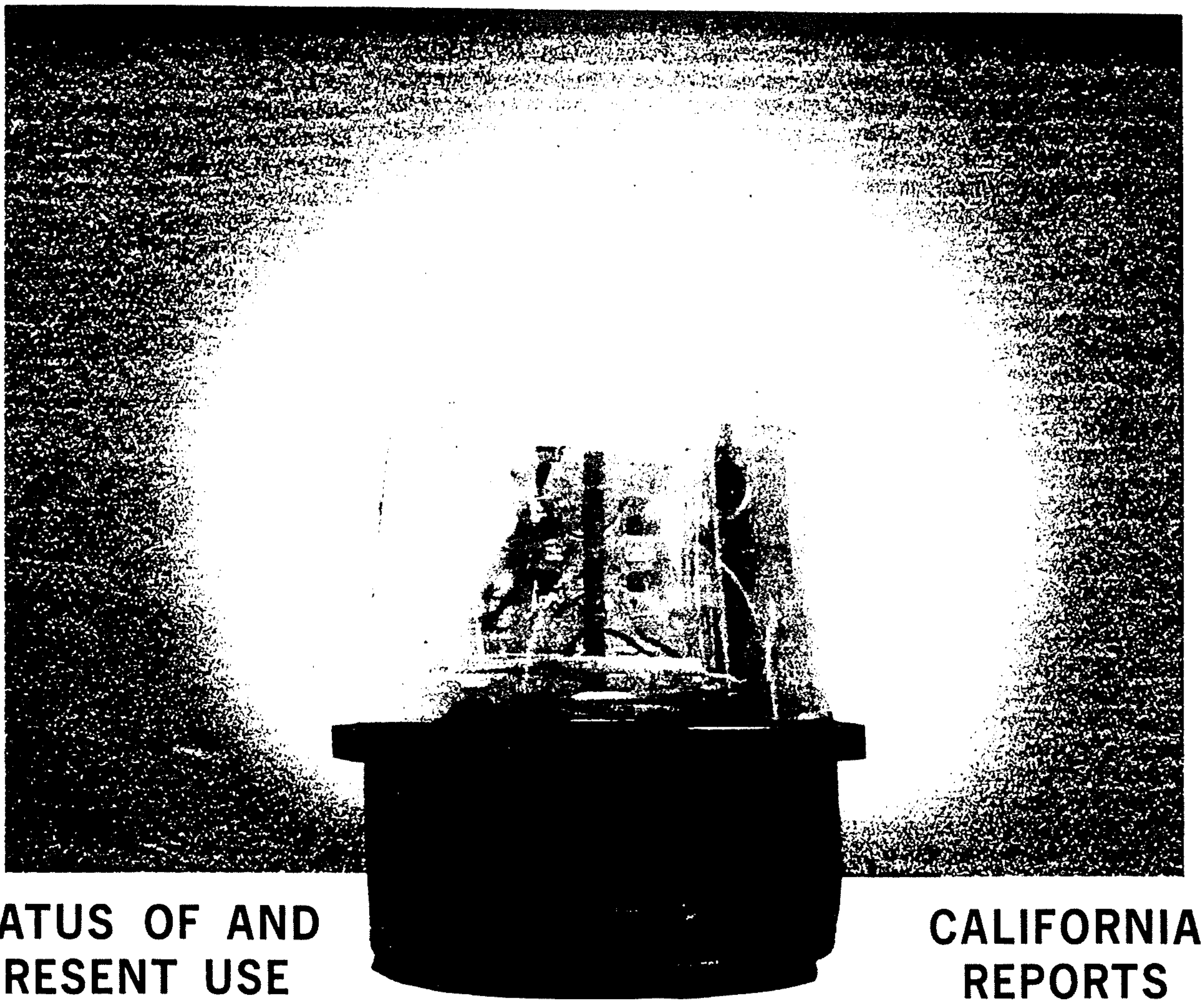
Average of 6 points at .39 ratio = 76%

Average of 4 points at 1.19 ratio = 20%

Average of 5 points at 1.72 ratio = 10%

I look forward to your comments! Best regards.

Ken Menke August 23, 1987



BLUE LIGHTS

STATUS OF AND PRESENT USE

Reported By
S. LAWRENCE PAULSON
Writer/Editor
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Gaithersburg, Md.

RED has traditionally been the color of emergency lights on police cars. Red is also the color of backup lights, stoplights, warning lights on school buses, and many other emergency warning signals found on the road.

For this and other reasons, the use of blue lights on police vehicles is becoming increasingly prevalent. A number of states have adopted blue, or a combination of red and blue, as the standard color for police emergency lights. But the subject is still highly controversial. In 1971, the National Committee on Uniform Traffic Laws and Ordinances had to postpone taking a position on blue lights because of the strong opinions on both sides of the question. And the debate still rages.

Red lights are still favored by the majority of states. A recent survey by the International Association of Chiefs of Police showed that the color of

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CALIFORNIA REPORTS

Reported By
WALTER PUDINSKI
Commissioner
California Highway Patrol
Sacramento

THE SEARCH for an all-purpose emergency warning light which offers adequate protection to the police vehicle has necessarily been intensified in recent years.

Profusion has led to confusion, and with it considerable loss of both recognition and impact for the traditional warning symbols, which in the state of California are red and/or amber lights. The number of special vehicles displaying red or amber warning lamps has grown significantly—including utility company trucks, tow trucks, and highway maintenance vehicles, in addition to such traditional emergency vehicles as ambulances, fire trucks, and police vehicles.

The roadside panorama compounds the problem, particularly in urban areas where commercial lighting devices wink invitingly yet often imply a false emergency message. The aver-

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BLUE LIGHTS
CALIFORNIA REPORTS

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age city driver faces a constant barrage of competing lights; recognition of traffic signals can even be confusing.

Reestablishing the integrity of the emergency warning light initially demanded an exhaustive evaluation. Therefore, the California Highway Patrol recently conducted a dual investigation—first, to determine which color and type of lamp were most visible under various lighting conditions; second, to ascertain which light would have the most significant effect upon traffic, since the basic task of any emergency warning light is to alert oncoming drivers to potential problems ahead.

Red lights have long been subjected to modest criticism, based on psychological research which indicates that (1) approximately two-thirds of the population perceives red objects as being farther removed than they actually are; (2) some portion of the public is subject to red-green color blindness; (3) at low levels of illumination, reaction is slower to a red light; and (4) red is an "arousing" color.

The color blue, on the other hand, creates a faster reaction time and is less "arousing." While this evidence on the surface mandates a switch to blue lights, a 1964 California Highway Patrol study indicated otherwise, when a blue dome light was tested with disappointing results. The blue light failed to provide adequate recognition and was not consistently visible. Viewed from the front, it washed out badly when competing with vehicle headlamps.

The intervening nine years have seen a major advance, however, with technology providing the blue strobe light (often identified as gaseous discharge) plus improved blue spotlights and blue revolving lights. In addition, red strobe lights have also become available. Thus, the Patrol's most recent test incorporated each of these as well as the standard red and amber sealed beam units.

The initial experiment was a simple visibility test to ascertain the maximum distance at which each light could be seen. Lights were attached to a light bar mounted on the roof of a patrol vehicle (as they were for all subsequent tests).

Observers took a position 4500 feet from the lights, moving toward the vehicle in 250-foot increments. All lights were visible at this 4500-foot distance under every condition—bright sunshine, darkness, and daylight overcast—with three exceptions. In sunshine, the blue strobe could not be seen until observers reached the 2700-foot mark; the blue revolving and the red sealed beam became visible at just under 2000 feet. The rankings of the individual lights tested under different light conditions are shown below *in descending order of visibility.*

Daylight

1. Red Strobe
2. Blue Spotlight
3. Amber Sealed
4. Blue Strobe
5. Blue Revolving
6. Red Sealed

Darkness

1. Blue Strobe
2. Red Strobe
3. Blue Spotlight
4. Amber Sealed
5. Blue Revolving
6. Red Sealed

A subsequent test paired up various combinations of lights. All were observed within the visibility range set by the initial evaluation. Lights were flashed alternately, then in combination. In this test, the benchmarks were "noticeability" or "attraction"—a measure of which type overpowered or reinforced the other.

The blue strobe/red strobe combination indicated clear dominance for the blue at night and the red during the day, with a standoff under overcast skies. The blue strobe dominated the red sealed beam under every condition of lighting, except when the two were operating simultaneously—then the red sealed beam tended to reduce the effect of the blue strobe.

In both pairings of the blue spotlight with sealed beam lamps—red then yellow—the results were mixed until both lights were flashed together. In each case the effect was reinforcing,

BLUE LIGHTS STATUS AND USE

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police lights is set by statute in many states, and few police officials seem sufficiently dissatisfied with present laws to argue for their change. Few state officials appear to have compiled available studies comparing the effectiveness of red and blue lights, or to have authorized tests of their own.

One of the exceptions was in the state of California, where the Highway Patrol compiled a detailed report on blue lights. Visibility testing was performed on six different types of lights in both daylight and darkness: red and blue strobes, red and amber sealed beams, blue spotlight, and blue revolving light. The report concluded that:

- A blue lamp is not a good substitute for a red lamp in daylight.
- A blue spotlight does not have a sufficiently broad beam pattern.
- A blue lamp must have a good deal more brightness than an amber one for equivalent brightness.
- The combination of one red and one blue strobe light provides the most effective stationary visibility, but is the most expensive device.
- A combination of the blue revolving lamp and the red warning lamp improves the stationary nighttime visibility of the present red warning signal.

As a result of the study, it was recommended that the department consider installing a blue lamp in addition to the red one on patrol cars equipped with an overhead light bar.

A study was also conducted by the Maryland State Police, which recommended installation of a bar of two red and two blue bulbs covered by a clear dome. The study concluded that this configuration "provided maximum light and contrast." The superior visibility of blue lights at night and red during the day was also cited. Following the study, the red-blue light combination was installed in state police cars.

The state of Michigan used studies by Dr. Glenn A. Fry, of the Ohio State University College of Optometry, as the basis for rejecting the use of blue lights. Dr. Fry's study showed that blue and white light of the intensity used on patrol cars would bleach the retina to the point of causing a loss of visual night sensitivity after a brief exposure. Depending on the age of the individual, Dr. Fry found, this effect could last for several minutes. The study concluded that red light does not cause such bleaching.

The state of Connecticut, in early 1971, conducted field tests on different colors of warning lights. Blue strobes were overwhelmingly preferred by the troopers involved in the tests. Corporal Patrick F. Hedge, of the Research and Planning Division of the Connecticut State Police, said that blue was selected "due to its warning capabilities." He said the strobe "allows a motorist to observe the light beams over the crest of a hill and around a corner. Since the widespread use of the strobe light by our troopers we have decreased our accident rate by 20 percent."

Corporal Hedge also said the number of vehicles using red lights have decreased the effectiveness of the color for police use. He said that among the few negative comments from the public on the use of blue lights have been the complaints that the light is too bright and does not offer a good reference point for the motorist who is approaching it.

Bills have been introduced in the state legislatures of Colorado and Ohio to permit the use of blue lights by police. According to Captain Clifford R. Kimber, the Ohio State Highway Patrol opposes the idea on the basis of "uniformity and consistency." He said the department believes all emergency vehicles should use the same color lights. He also said blue has the poorest visibility of any color at a distance, creates depth perception problems, and produces scattered light under adverse weather conditions.

The official position of the IACP on the subject of police lights was adopted in 1967 and is based on a National Bureau of Standards research report. The IACP urges all police departments to use red lights and to "do all in their power to curtail the use of red lights by all vehicles" except police cars, fire trucks, school buses, ambulances, and "rescue vehicles designed or utilized for the principal purpose of supplying resuscitation or other emergency relief where human life is endangered." The IACP's position is that "red has ever been accepted by the public as a sign of danger and associated with the police on emergency missions.*

Avery T. Horton, emergency equipment program manager for the National Bureau of Standards Law Enforcement Standards Laboratory, said, "The issue of blue lights is very controversial at this time. Different organizations and different individuals assign different priorities (to various arguments for and against blue lights), and achieving a consensus has been difficult."

Horton said the three most common arguments in favor of blue lights are:

1. The eye is more sensitive to blue wavelengths than to red or yellow in peripheral vision.

2. Many European countries use blue lights, so adoption of the color in the United States would promote international uniformity.

3. There are now few blue lights on the highway, so the color is distinctive as a warning light.

*

The trend toward blue lights is not likely to reach landslide proportions but an increasing number of states are considering the red v. blue question.

*

The three most common arguments against blue lights, Horton said, are:

1. Blue is not widely recognized in this country as conveying a sense of danger or emergency. There is no history of the use of blue as a caution or stop signal as there is with red and yellow.

2. Blue domes transmit a small fraction of the luminous energy emitted by incandescent lamps, making it necessary to use more powerful lamps drawing more electricity. Strobe lamps put blue on more even terms with red, but are relatively expensive.

3. Since blue lights are not as common as red or yellow, nationwide standardization on blue would cost more than red or yellow.

Although it is unlikely that the trend toward blue lights will reach landslide proportions, the controversy will doubtless continue as an increasing number of states question the conventional wisdom that red is the only color of light appropriate for a police vehicle. ★

**Highway Safety Policies for Police Executives*, Highway Safety Division, International Association of Chiefs of Police, p. F-35.

"noticeability" was ranked high, although the blue light was the dominant factor. A comparison of the blue revolving light with a red sealed beam brought a similar finding.

Peripheral visibility was also established for each type of light, with blue the most effective—strobe at night and spotlight during the day. A final visibility test was conducted against a wooded background in contrast to the urban setting selected for the first three tests. Visibility of all lights tested was generally enhanced in this rural environment.

The red and blue strobe lights—offering great promise—were selected for comparison with standard red and amber sealed beams in the traffic response experimentation. In this phase, the capability of each type of light to reduce traffic speeds and to deflect traffic from the outside (or curb) lane was measured.

The settings were broadly contrasting. One was a two-lane, two-way road with narrow shoulders; the other was a multilane freeway (three lanes in each direction) with a broad shoulder. The patrol vehicle was parked three to five feet off the roadway with emergency warning lights flashing. There was no indication to the approaching motorist that the patrol vehicle's presence represented anything but a typical situation—apprehending a violator or investigating an accident. The tests were conducted in both daylight and darkness.

Speed reductions were most dramatic on the two-lane road, where no other practical response was available. The mean drop ranged from 8 to 14 miles per hour. Freeway speeds (in the outside lane, the only lane of concern) declined from 1½ to 2½ mph in daylight, and the overall mean speed actually increased slightly during darkness.

The red strobe light produced the greatest effect on speed during daylight hours in both locations. The blue strobe had the greatest impact at night on the freeway; curiously, the yellow sealed beam was slightly more effective than the blue strobe on the two-lane road, although the edge was not statistically significant.

The movement of traffic away from the outside freeway lane—an alternative denied motorists on the two-lane road—was dramatic at night, but lessened considerably during daylight hours. The switch to an alternate lane approached 90 percent of all vehicles at night when the red strobe was displayed, while the maximum change occurring during daylight hours was 30 percent, resulting from the blue strobe. This result in itself was interesting, in view of accumulating evidence that the red strobe was the optimum daylight device and the blue strobe was most effective at night.

General superiority of the strobe-type lights throughout the series of tests suggests conversion to this type of warning device, although to secure maximum advantages both red and blue would be required. The visibility tests, which placed red and blue in combination, indicated that the positive effects of both can be obtained without diminishing the authority of the dominant light—red during daylight and blue at night.

This postulate has not been tested in dynamic circumstances, however, and the next phase in experimentation should be to put red and blue lights in combination for study under field conditions. The California Highway Patrol proposes to evaluate this aspect and recently ordered a large quantity of light bars which incorporate the red-blue lighting combination. It is anticipated that by fall, 1973, a substantial number of Californians will have a chance to react to the new warning lights. ★

SEPTEMBER 27, 1990

		RED LIGHTS	BLUE	WHEN	DID STUDY	USE SOMEONE'S	WHY
1.	Cincinnati OH		X	1986 State Law	No	No	Elim. people impersonating
2.	Dayton OH	X	X	1986 State	Unknown	Unknown	Unknown
3.	Long Beach CA	X	X	1980's	No	Unknown	See blue light
4.	Norfolk VA		X	1987 State Law	No	No	Seen easier
5.	Oklahoma City OK	X	X	1980	Unknown	Unknown	Visibility
6.	Phoenix AZ	X	X	1979/80	No	Unknown	Colors seen Govt guidelines
7.	Richmond VA	X	X	1985	Unknown	Unknown	State Law
8.	Sacramento CA	X	X	1980	Unknown	Unknown	Red to front Steady Burning State Law
9.	St. Petersburg FL	X	X	10 years	Unknown	Unknown	Unknown
10.	San Antonio TX	X	X	1980	Unknown	Unknown	Better Visibility
11.	San Jose CA	X	X	17 years	Unknown	Unknown	Unknown
12.	Toledo OH	X	X	1986 State Law	Unknown	Unknown	Unknown
13.	Tucson AZ	X	X	1985	Unknown	Unknown	Unknown
14.	Virginia Beach VA		X	phasing	No	Unknown	Easier Seen

Effective Warning Light Systems

Characteristics of highly effective warning light systems.

Andrew G. Smith
Vice-President, Engineering
Public Safety Equipment, Inc.
Summary of a presentation to the National Police Fleet Administrators
Ottawa, CANADA
August 8, 1990

In order to effectively evaluate the various types of warning light systems available today requires an understanding of some of the basics of lighting science. Lighting engineers use the term, "Conspicuity", to describe the ability of a flashing warning light to capture the attention of a viewer. There are three primary factors that account for the ability of a warning light system to command a viewer's attention: (1) the light output of the device, (2) the color of the light emitted, and (3) the flash rate, or what I like to call "activity level".

Light output

For years, we have long been told that "candlepower" is the primary measurement of light intensity. Although it may be an accurate measurement of light intensity, candlepower or "candela" is not an effective way of comparing the **visual** performance of light sources. The correct way to measure the total amount of light energy present is a method called "flash energy". Perhaps the best way to explain 'flash energy' would be to explain how a light meter would measure flash energy.

Figure 1 represents how the light output signals from a Strobe and Halogen warning light source would look on a graph. Notice the strobe light produces a very tall, but narrow burst of energy on the graph, showing a very high peak intensity for about 250 microseconds (a microsecond is .00001 of a second). Compare that with the halogen light flash. Although the peak intensity of the halogen light is only about 1/20th of the strobe light source, the duration of time which the halogen light is on is 100 times that of the strobe. On the graph, it's easy to see that the area under the halogen curve meets or exceeds the total flash area of the strobe signal.

The Society of Automotive Engineers (SAE) ran a test to determine if the mathematical comparison shown by the graph actually made a difference to people who would see the light. The SAE task force compared a halogen rotating light and a strobe light of the same flash energy, flash rate, and color. A body of viewers were asked to stand at various distances and note which of the two light sources appeared to be brighter. The group could not tell the difference between the two light sources. When asked to identify which light was the halogen and which was the strobe, the viewers could not determine which light was which, even from relatively short distances. The result - lights of the same flash energy, same flash rate and same color were perceived to be of the same brightness and were judged to be equally effective.

Colors That Command Attention

The second factor in determining the effectiveness of a warning light is it's COLOR. Several factors must be noted when selecting the most effective color: 1) Transmittance - the amount of light which will pass through a colored filter. An amber filter will allow 60% of the halogen light to pass through. Red filters allow about 25% of the light to pass, while blue filters allow only about 15 % of the light to shine through.

These figures should give you a pretty good idea which lights would be most visible from a distance. Using the same light source behind the filters, white will appear to be the brightest followed by amber, red, and finally blue. But all the research has not been able to accurately measure the way the human eye perceives light. Surveys of volunteers have shown that the human eye is more sensitive to reds in the day and blue at night. SAE investigated this human phenomena to determine how

Flash Energy Comparison: Halogen vs. Strobe

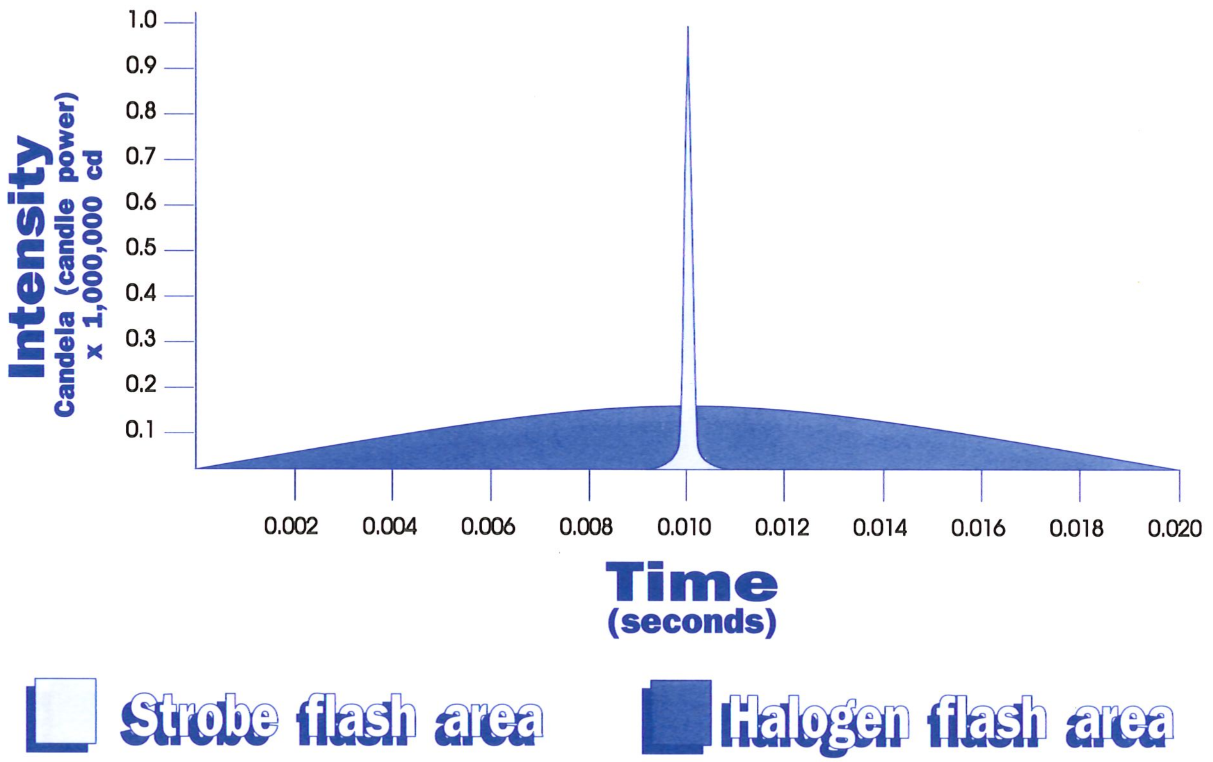


FIGURE 1

the difference in sensitivity to color affected the way humans view flashing lights. We found that twice the amount of blue light energy is needed in daylight to be perceived as equal in brightness to a red light. At night, the situation is reversed and only one-third the amount of blue light energy is needed to be perceived as of equal brightness as a red light.

> ***...the human eye is more sensitive to red in the day and blue at night.***

This strongly suggests that the best combination of primary warning light colors for emergency vehicles is a combination of red and blue - red for daytime viewing, blue for night.

There is another important factor in considering color - the message that various colors transmit. Depending on the jurisdiction, red, blue, or a combination of red and blue, transmit the message - "Emergency vehicle, be prepared to yield or stop." Amber light should not be overlooked as an effective warning signal. Amber light is about twice as bright as red and four times as bright as blue light. It is an extremely effective, long-range warning color. The other advantage about a flashing amber light is that it relays a very specific message to those who view it - "Prepare to yield or merge". Also, amber lights can be sequenced as in an ArrowStik^{TM} type device to generate an arrow to very effectively direct traffic in specific directions.

Color temperature

The "Color Temperature" describes how much of the various colors in the light spectrum are contained in a given light source. The term is derived from the fact that when a tungsten filament is heated it begins to glow - first red, then yellow, then white and finally blue.

The temperature of a glowing filament in "degrees Kelvin" can be directly related to the color content of the light being emitted; thus the term "Color Temperature". It is important to draw some contrasts between halogen and strobe light sources. Halogen light has a color temperature in the 2,000 to 3,000 degree Kelvin range - a light containing quite a bit of red. Strobe light sources, on the other hand, have a much higher color temperature -

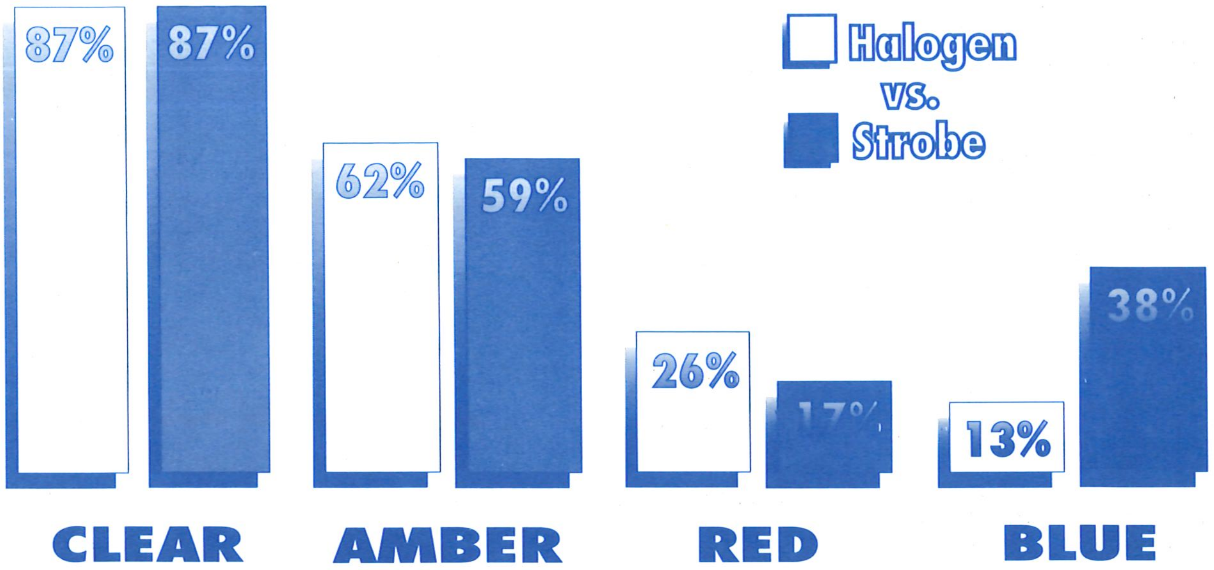


FIGURE 2

5,000 to 6,000 degrees Kelvin - very close to the color temperature of sunlight. As a result, the strobe light tends to blend with the daylight and often appears very dim in bright daylight. The other problem with a strobe light appears when you place a red filter in front of a strobe light source. The filter removes all the light in the color spectrum other than red. Since strobes contain a high degree of blue, most of the light energy is absorbed by the red filter. In fact, most red strobes signals barely meet minimum SAE and California requirements.

> ***In fact, most red strobe signals barely meet minimum SAE and California requirements.***

That is why many red strobe light lenses are now pink in an effort to get more flash energy out of their signal. This "double whammy" diminishes the effectiveness of a strobe light in the toughest, but most common warning light situation - bright daylight.

Foveal and Peripheral Vision

The next factor in determining a light's conspicuity is the light's activity level or Flash Rate. Here again, the way the human eye processes what it sees has a great effect on the warning light's effectiveness.

There are two components to our vision - the FOVEAL or 'forward' vision which allows us to focus, read, and see detail and PERIPHERAL or 'side' vision which is very sensitive to movement but does not allow you to read or clearly focus on objects. You must turn your head and focus your foveal vision on an object to perceive it's shape or meaning. As a kid playing ball, you may remember when a ball approached you from the side, your peripheral vision detected the motion, told your mind to turn your head so your foveal vision could focus on the ball and allow you to react to the danger. This is a natural defense mechanism.

This suggests that for maximum impact, a warning light signal needs to contain: 1) a very high flash energy to allow the light to be seen from a distance, and 2) a very high activity level - lots of action, flash rates and changes of color so it can be quickly picked up by the peripheral vision.

In the old days, the first warning lights were a steady red light. We then began to flash that red light to increase the light's ability to capture the attention of viewers. Someone figured out that if you rotated that light source, you could get the attention-grabbing effect of a flashing light and provide equal coverage all the way around the vehicle. Then "light bars" were developed which gave us a format to mount various warning light devices. Today, we are finding that activity level can be further improved by varying the flash rate while maintaining a constant flash energy. SAE tests were conducted to determine the effect of flash rate.We found that if we maintained a constant flash energy such that every flash produced was of equal energy and then increased the number of flashes produced, the conspicuity increased considerably. The test called for maintaining a constant flash energy, but if you increase the number of flashes of a strobe light during a specified period of time or increase the spinning rate of a rotating halogen light source, you provide more flashes but each flash is of lower flash intensity and lower flash energy. It is crucial that you keep the flash energy relatively constant while increasing the flash rate to raise the conspicuity of a warning signal. Code 3® has capitalized on this concept by taking a conventional rotating light source and, through a switching means, oscillate it through a 100 degree arc. Since the rotational speed of this oscillating light is the same as when it rotates 360 degrees, every flash that it produces is of the same flash energy. The difference is the oscillating light produces a tripling or quadrupling of the number of flashes. Anyone who has seen the StingRay™ in action has realized that this is the highest combination of flash energy and flash rate available in any device currently available in any light bar on the market.

Designing the effective warning light

A warning light system serves two functions. First, it alerts motorists that an emergency vehicle is present. Secondly, a warning signal needs to continuously broadcast the location of the emergency vehicle in such a manner that viewers can identify its speed, location and direction of travel.

A strobe light produces a very intense light for a very short period of time and is then "off" for a lengthy time. The long "off" time makes it difficult to track the location of a rapidly moving emergency vehicle. This is especially true for elderly persons, the physically impaired and those impaired by drugs or alcohol. It requires a higher level of concentration to locate and track a strobe equipped vehicle. This situation can be improved by double flashing the strobe light source, but you are still left with an extremely long "off" time.

It requires a higher level of concentration to locate and track a strobe equipped vehicle.

Rotating signals, on the other hand, provide a strong primary signal and strong secondary signals off mirrors and other devices that lengthen the dwell time of the flash. And since the rotating light source has a continual output, the light bounces off buildings, cars and other obstructions, so it is easy to continually mark the location of the emergency vehicle. In addition, rotating light systems emit a continual glow of light from their lenses even when the light signal is not pointed at the viewer. This would suggest that if you are using directional strobes, you need to combine the strobes with a rotating light signal to provide a constant marking light locating the emergency vehicle.

When designing an effective warning light system, we need consider the response we want the warning lights to evoke. The messages the emergency vehicle send may be different ranging from the long-range signal of an emergency vehicle requesting that viewers take note of its location and direction of travel to the short-range demand that a driver take immediate action to yield to the emergency vehicle. The accompanying chart, Figure 3, shows the varying situations that confront emergency vehicles, the messages the warning light systems need to convey in each situation, how the signal is first sensed by the viewer, and finally, how you, as a user of warning light systems, might be able to improve the viewer's response to the warning light.

In long-range warning situations, you want to send the message that an emergency vehicle is approaching. You want to send the message that they should observe your location and speed and should prepare to yield when the emergency vehicle approaches. The long-range signal is detected by the forveal vision of the drivers which we are approaching head-on. To attract the attention of drivers who you are approaching from behind, your warning light source needs to penetrate the rear window, reflect off the rear-view mirror and be sensed by the driver's peripheral vision so that the foveal vision can be triggered to focus on the light source. How do we do this? First, we are looking for maximum long distance warning which is achieved by high flash energy light sources: oscillating lights, flashing headlights, long flash duration stationary directional lights (halogen or strobe). The first choice of color would be white to provide the maximum flash energy level, followed by red for day and blue for night.

The first choice of color would be white to provide the maximum flash energy level, followed by red for day and blue for night.

Fig. 3

CONDITION	MESSAGE SIGNAL MUST SEND	HOW SIGNAL IS FIRST NOTICED	METHOD
Long-range forward warning.	Emergency vehicle approaching. Observe location & direction of travel. Prepare to yield.	Opposing Approach: Foveal vision. Approach from rear: Peripheral vision. (Relatively "long" period of time to respond.)	High flash energy signals: High flash energy oscillating lights with white light facing front. High flash energy oscillating lights with red filters (day) & blue filters (night) for recognition as an emergency vehicle. Flash headlights (day). Long duration flash. Stationary directional flashing lights—halogen or strobe in red (day) & blue (night). Rotating signal in red and/or blue to provide long dwell, for secondary light signal to constantly mark vehicle location.
Short-range forward warning. Congested traffic.	Emergency vehicle present—Quickly clear right-of-way.	Opposing Approach: Foveal and Peripheral vision. Approach from rear: peripheral. ("Short" period of time to respond.)	Super High Concentration of high-contrast lighting—high flash rate & high flash energy signals. High flash rate & flash energy oscillating lights to provide zero "off-time" high contrast signals quickly perceived by target vehicle operator. White color of preference for maximum effect. Red next best for day lighting. Blue next best for night lighting. Effective to "blast" these signals for short durations, along with a change in the siren tone to denote the event changing from emergency vehicle "coming" to emergency vehicle here **now.** Multiple colors provide additional contrast to surrounding conditions. Multiple rotating signals & reflectiing mirrors to provide secondary saturation of traffic scene and assure coverage of all sides of vehicle. Flash headlights at high rate.
Short-range 45°–90° off angle approaching intersections.	Emergency vehicle about to cross your direction of travel. Take action **now.**	Primarily peripheral vision. (Little to no time to respond.)	All of above and focus high flash energy signals directly at angle of approach. High output oscillators traveling 70° to 120° from center. White color of preference.
Emergency vehicle stopped alongside right of way. No danger in through lanes. Oncoming traffic need not slow. Minimize "rubber-necking".	Emergency vehicle present—proceed with caution. Do not stop.	Primarily foveal vision.	Rear only slow flashing lights. Amber highly preferable to transmit "caution" and "yield" rather than "stop" message. Slow oscillating light. Random or alternating flashing (not sequenced.) stationary directional light—halogen or strobe.
Emergency vehicle stopped on right-of-way—through lanes blocked—traffic must divert.	Emergency vehicle present. Proceed with caution around scene—move only right or split & move either left or right. Do not stop.	Foveal vision—Approaching traffic directly in line with scene.	Sequenced rear facing amber lights which build an arrow signal in necessary direction.
Traffic stop—night time.	To violator: **Stop.** Don't Move inside vehicle. Your actions are being observed.	Rear-view mirror—foaveal & peripheral vision.	(2) white takedown lights, facing forward.
Surveillance alongside cruiser without lighting devices blocking 360° warning signals.	(Stationary or moving surveillance of area.)	N/A	1 or 2 alley lights, each side.

A rotating signal in red and / or blue provides recognition as an emergency vehicle and long dwell secondary light signals constantly mark the vehicle's location. Unquestionably, flashing headlights are extremely effective warning signals in this application. Stationary directional lights can be effective in this case because you can accept a lower flash rate, giving a higher flash energy from the light source to provide a good long distance warning.

Out of the Way NOW!!

Of course, one of the most critical needs of emergency vehicles is the ability to communicate an effective short-range warning to vehicles in their path that "an emergency vehicle is not only in the area, but it is here right now! Move out of the way IMMEDIATELY!" In the case of short-range warnings, the warning signal most often needs to be sensed by the peripheral vision, because if the driver's haven't seen it with their foveal vision by now, they are undoubtedly looking elsewhere and you need to catch their peripheral vision. Given the very short time drivers have to react in this situation, you need to flood the area with a tremendous amount of high flash energy light flashes. Here, it's effective to blast the scene with an added layer of warning lights. Your best choice for highest flash energy and flash rate is an oscillating light source, blasting it for several seconds as needed, thereby changing the signal being sent by the lighting system from that of an "emergency warning" system to a high urgency "traffic clearing" signal.

But emergency vehicle accident statistics show that warning light systems have an equally important role in preventing the most common emergency vehicle accident - the intersection collision. As an emergency vehicle approaches an intersection, the warning light system must not only convey the message that "The emergency vehicle is present NOW", but also, "The emergency vehicle is going to cross your path, and you have to react instantly". To catch the attention of vehicles crossing the path of the emergency vehicle, you must use lighting systems that instantly captures the peripheral vision attention of drivers approaching the emergency vehicle's path. Here you must utilize all the warning methods previously mentioned and also focus a constant, high flash energy, high flash rate light source into the upcoming intersections at a 45 degree angle forward of the emergency vehicle. Here, dual oscillating lights that are concentrated at 45 degrees off to both sides emitting a continual signal prove to be an extremely effective intersection warning system.

Intersection warning is the most critical warning situation emergency vehicles face.

Almost as important but not quite as urgent is the need to warn motorists that they are approaching a stationary emergency vehicle which is stopped. Your main objective here is, of course, to prevent a rear end collision into your emergency vehicle. You want to minimize the signal sent forward to avoid creating a "rubbernecking" situation, but you want to send a clear signal to the vehicles behind you that there is an emergency vehicle ahead, and they need to be prepared to detour or merge around the scene. Here, an amber light source is extremely effective. The amber signal provides excellent long-range warning and sends a cautionary, rather than a stop message.

The same recommendations hold true where a traffic lane is blocked either by an emergency vehicle or disabled vehicle, however, a slightly higher level of urgency exists. In this situation, you have to provide very specific directions to traffic. You want traffic to slow and be aware of the situation and then know which direction to move around the emergency situation. Here the amber light sequence in an ArrowStik type device can send a very specific message for traffic to move either left or right or in both directions around the scene. Additional situations and lighting recommendations are listed in Figure 3.

A Few Words About Strobe Systems:

In comparing Strobe and Halogen light sources, several characteristics of Strobe light sources should be noted:

- Strobe lights provide a clear, strong blue signal, especially visible at night. However, it must be noted that due to the color temperature of a strobe light, the same blue signal that is highly visible at night is extremely poor in daylight because it is washed out by the sun.

- As a red light source, strobes have very poor photometric performance.

- Strobes can often provide long-distance penetration in adverse weather conditions such as fog, snow, and rain. This is good for stationary emergency vehicles trying to provide a long-distance warning in these conditions. However, the strobe may actually become a disadvantage when driving an emergency vehicle in the adverse weather. The extremely short duration of the strobe light tends to freeze the action of anything moving around it such as snowflakes. The strobe flashes reflecting off the snow, fog or rain may blind or disorient the emergency vehicle operator.

-The high cost of strobe lights often results in fewer lights being used in a strobe system to keep the system competitively priced. The smaller number of strobe lights in the system means the system will consume less current. However, when comparing lighting systems by their ability to provide equal lighting performance, the strobe system will often cost double that of an equal performance halogen system. The important point to be noted here is that individual halogen light devices provide equal, and in many cases, higher flash energy light performance than strobe components.

The power output of a strobe power supply and the light output of a strobe flash tube continually diminish over time.

A Few Words About Halogen Systems:

In evaulating halogen warning light systems, several characteristics must be noted:

- Halogen light sources work best in red warning lights to provide an outstanding daytime signal.

- The reds produced by halogen lighting systems provide two to three times the light output of red strobe light systems.

- Halogen lighting systems offer the highest flash energy of any light source currently on the market.

- In comparing halogen and strobe lighting systems that draw the same amount of current, the halogen light system will provide equal or greater light output.

- The wide variety of halogen lighting systems available today can be confusing and lead to the purchase of a system that may draw an excess amount of current. You should keep in mind that halogen lighting systems provide a tremendous amount of flash energy for the amount of amperage used. If the lighting requirement demands the maximum warning light effectiveness, a halogen light system provides the highest flash energy devices available.

Comparing Lighting Systems:

To bring this comparison problem in focus, let's look at two popular warning light systems as noted in Figure 5. The popular strobe bar contains eight light heads and two power supplies. The halogen system contains 2 - 100 flash per minute (FPM) rotators and a 160 FPM rotator in the center position. The strobe light produces 280 primary flashes and 280 secondary flashes per minute, both front and rear. This strobe light system is equipped with portions of strobe tubes pointed out the end, separated by an alley light. With this particular system, the end strobes must flash together in order to produce enough light energy out to the side to meet the minimum SAE and California Lighting requirements. Since the end strobes flash together, you get a total of 70 primary and secondary flashes out of the sides of this lighting system.

The halogen system, on the other hand, provides 360 primary flashes and 1,240 secondary flashes to the front. The secondary flashes reflect off the mirrors located within the lighting system. This system also produces 360 primary flashes to the rear and 100 flashes per minute to the side. Comparing the flashes produced by these two systems, you find the strobe lighting system produces 560 primary and 560 secondary flashes compared to 920 total primary and 1,240 total secondary flashes per minute for the halogen system. That means the halogen light bar produces 1.6 times more primary flashes and 2.2 times more secondary flashes - for about half the cost of the strobe system.

Both systems in this comparison draw 12 Amps. Since the halogen light system provides a higher number of flashes of equal or greater flash energy per flash at about half the cost of the strobe light system, which would you consider to be the best value?

Maintenance Considerations:

The power output of a strobe power supply and the light output of a strobe flash tube continually diminish over time. The light output of a strobe light source can drop below the SAE and California required minimums; particularly, in red lights. To maintain minimum light output levels, the power supply and flash tube would have to be replaced long before the units stopped emitting light. Since most units are not easily serviced, you may have to ship the power supply back to the factory. In the end, light servicing will cost you $ 250 to $ 300 for a new power supply and $ 50 for each flash tube, not to mention the down time you suffer while the unit is being serviced.

The simple design of the halogen system and the natural benefits of halogen lights make for easier, lower cost maintenance. The rotating mechanism of the average halogen warning light system typically out lives 3 to 4 police cruisers. Some systems, such as the Code 3 system, are permanently lubricated and last for the entire life of the system without maintenance. The only

Strobe +'s

Best performance in blue. Outstanding at night.

Long distance penetration in fog/snow good when emergency vehicle is stopped.

Amber signal good.

Cost of systems tend to limit number of lighting devices = limited current consumption.

Most flexibility in flash rates & device sizes for stationary fixed directional lights—often best choice for directional light applications.

Low maintenance due to no moving parts (perception).

Long light source life (flash tube).

Halogen +'s

Best performance in red—suggested for daytime usage.

Blue signal outstanding at night.

Amber signal excellent. Twice the energy level of red.

Strong secondary flash—easy to locate & track. Greater impact on impaired people.

Highest flash energy levels currently obtainable. Red, 2 to 3 times that of strobe levels. Blue, 1.5 times that of strobe. Amber, 1 to 3 times that of strobe levels.

Equal light output with same current consumption, but half the cost of strobe systems.

Higher light output with high current consumption easily obtained.

System user maintained by:

Bulb only maintenance item (other components typically outlive several patrol cars).

Bulb & rotator easily changed.

Bulb change is only component required to provide SAE & California minimum output levels for up to 10 times longer than typical strobe system.

One light source failure has no effect on other light sources.

RFI suppression built in to motors.

Rotating light concentrates its full light energy into a narrow beam & distributes it 360°, providing full flash energy to all points surrounding vehicle.

Only effective way of providing takedown & alley lights.

Capable of highly effective "ArrowStik™" type of traffic directional lighting device.

Strobe –'s

Blue signal "lost" in daylight. Intensity must be lowered at night.

Poor red signal.

Disorienting to emergency vehicle driver in fog/snow. "Stops" snowflakes in motion and creates high glare from reflected light.

Short duration flashes disorienting—particularly to physically & mentally impaired. Requires concentration to follow.

Cost typically twice that of halogen systems. 2-3 times if compared on a light output-per-dollar basis. Performance roughly equal if compared on a light output-per-electrical current-consumed basis.

Power supplies degrade over time. Capacitors highly stressed, tubes degrade over time. Both combine to significantly lower output as system ages.

Process is gradual, unnoticed. Light output drops below min. spec. levels. Power supply and flash tubes should be replaced long before the light output ceases, in order to continue to meet SAE & California output requirements.

Power supplies costly: $250-300. each.

Power supplies not user-repairable.

Flash tubes expensive: $45+

Radio frequency interference (RFI) common. Requires additional cost options to suppress, and sometimes complex troubleshooting.

Failure of power supply shuts down up to 4 light heads.

Strobe devices only effective as directional warning. To cover 360° requires multiple light units with some angle of coverage—can't utilize mirrors to enhance coverage.

Unable to provide an understandable strobe traffic directional lighting arrow.

Halogen –'s

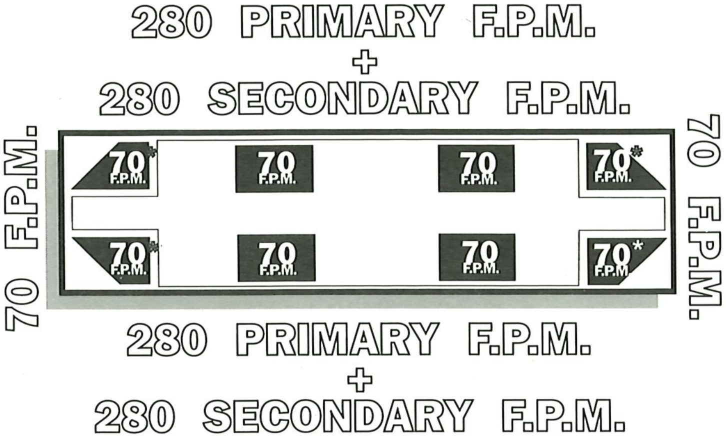
Blue signal "lost" in daylight.

Bulb life.

Large number of devices & output levels available sometimes lead uninformed purchaser to "over-specify" high-current devices.

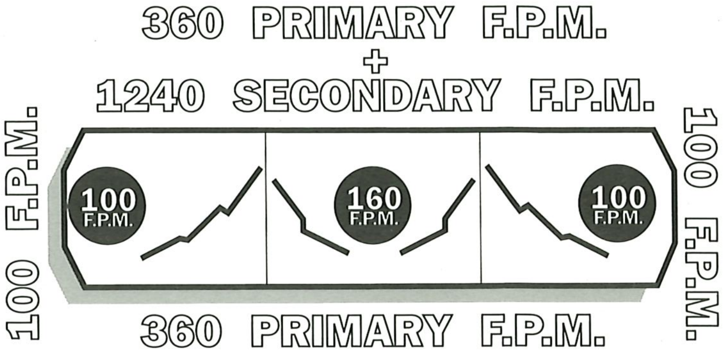
Fig. 4

Whelen 9308
Strobe System
Amp Draw: 12 amps
Price: $1,160.00



*End lamps must flash together to meet minimum SAE and California light output requirements.

CODE 3 5320 AF
Halogen Rotator System
Amp Draw: 12 amps
Price: $580.00



The Results:

STROBE
TOTALS:
560 Primary F.P.M
560 Secondary F.P.M.

VS

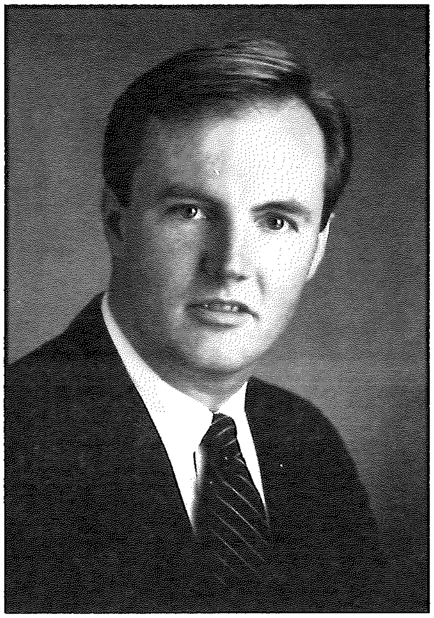
HALOGEN
TOTALS:
920 Primary F.P.M
1240 Secondary F.P.M.

routine maintenance item on a halogen system is the light bulb, but the natural characteristics of halogen bulbs give halogen systems a very positive advantage. When first lit, a halogen bulb slightly increases in light output over a period of time before light output levels off. The light output eventually drops off, but usually drops no more than 1 to 2 percent before the bulb burns out. The high output characteristics of halogen bulbs allow halogen light systems to maintain required light output levels for up to ten times longer than a strobe light system without replacing major components.

Last, but Definitely not Least

It is not uncommon for radio frequency interference to accompany strobe light use. It often requires some rather complex and costly troubleshooting to identify and suppress the interference. On the other hand, quality halogen lighting systems such as the Code 3 warning light system have radio frequency interference suppression built into every system.

Warning light systems should be tailored to the demands of the specific emergency vehicle. Color, flash energy, and flash rates need to be weighed in the decision which warning light system best suits your needs. And finally, maintenance considerations should be weighed before making your purchase. There are instances when strobe light systems are ideal, but in most cases, the lower cost, lower maintenance halogen light systems will fill your warning light system needs and leave you with more of the extremely difficult-to-get funding left for other crucial needs.



A Background Sketch of
ANDREW G. SMITH
PUBLIC SAFETY EQUIPMENT, INC.

Andrew (Drew) Smith is Vice President of Engineering of Public Safety Equipment, Inc., better known in the trade as Code 3®.

Drew has been involved in numerous industry and governmental standard writing bodies for emergency warning lights and sirens, including: The Society of Automotive Engineers (SAE); Fire Apparatus Manufacturers Association; Federal KKK-1822 Standards for Ambulances; ASTM Ambulance Standards and several state agencies formulating standards for emergency vehicle warning equipment.

Public Safety Equipment, Inc. is a leader in the design and manufacturing of state-of-the-art emergency warning equipment. Code 3 products are well known for their outstanding warning effectiveness and durability. Code 3 innovations have included:

- The highly effective StingRay™ multi-directional oscillating light.
- The multi-flash, multi-color Dashlaser, compact dash light.
- The ArrowStik™, which is the first effective traffic directing signal device designed to work in conjunction with emergency warning light bars.
- Innovative lighting and siren control systems, incorporating such featues as fiber-optic communication links and triggering mechanisms that switch both siren tone and warning light functions from a single switch.
- And most recently, the world's most advanced light bar system, the MX 7000™, which incorporates two independent levels of warning lights and contains such features as fast oscillating lights directed into intersections in front of emergency vehicle, over 15 stationary lighting positions, unobstructed 360° rotating warning light coverage and many other innovative Code 3 features.

THE CITY OF
EMPORIA

Civic Center / 522 Mechanic / P.O. Box 928 / Emporia, KS 66801 / 316-342-5105

February 19, 1991

Thank you for the opportunity to speak to you regarding House Bill 2106. My name is James Woydziak, and I am the Fire Chief of Emporia. The Emporia Fire Department covers the City of Emporia, and Lyon County Fire District #4, which is three and a half townships consisting of 210 square miles. We also provide ambulance service to all 858 square miles of Lyon County.

I wish to make some comments regarding the proposed change in emergency vehicle lighting requirements. If you look down any busy street, road or interstate at night, two things become very apparent very quickly. First of all, there are a lot of red lights out there. There are red tail lights, red brake lights, red turn signals and red stop lights. To compound this is the fact that many of these existing red lights flash at various rates and intervals.

The second factor that is readily apparent is the bright white headlights of all the on-coming vehicles. If an emergency vehicle were placed in this scene under existing laws, it's warning devices tend to make the vehicle blend in with all the other lights. This is because current law only allows either red or red and white warning lights on emergency vehicles. The only thing that distinquishes the emergency vehicles warning lights from all of the other lights is the frequency of the flashes in some cases. The presence of the emergency vehicle is often not very obvious until you are fairly close to the scene.

Allowing those agencies that wish to increase their visibility to use an alternate color - Blue - in their vehicle warning systems will only increase the safety of all involved. Not only would the emergency scene be safer for emergency workers, but for the general motoring public if they can be forewarned of the emergency scene.

I would like to ask the committee to consider a change in the bill. This change would allow blue lights on fire vehicles and ambulances. The current bill would only allow the use of blue lights on police vehicles. If blue lights would make police cars safer, it stands to reason that fire vehicles and ambulances would also be safer.

The wording of the bill makes it clear that blue warning lights would not be required, but that they would be an option. This, I think, is important. Those departments that decide not to spend any money to change to the safer lights are not obligated to do so.

House Transportation
2-20-91

ATTACHMENT 3-1