ACTIVITY SHEET

COMMITTEE: TRANSPORTATION

LD #: LD 464

TITLE An Act To Allow Fire and Emergency Medical Services Response Vehicles to Display One Blue Light at the Rear of the Vehicle

HEARING DATE: 2/25/03

WORK SESSION DATES: 3/7/03

REPORTED OUT DATE: 3/14/03

COMMITTEE REPORT: OTP / ONTP

121st MAINE LEGISLATURE

FIRST REGULAR SESSION-2003

Legislative Document **No. 464**

H.P. 356 House of Representatives, February 4, 2003

An Act To Allow Fire and Emergency Medical Services Response Vehicles To Display One Blue Light at the Rear of the Vehicle

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Reference to the Committee on Transportation suggested and ordered printed.

Millicent M. MacFarland
MILLICENT M. MacFARLAND
Clerk

Presented by Representative BULL of Freeport.
Cosponsored by Senator SAVAGE of Knox and
Representatives: ANDREWS of York, BUNKER of Kossuth Township, DUGAY of Cherryfield, MARLEY of Portland, McNEIL of Rockland, RINES of Wiscasset, STONE of Berwick, USHER of Westbrook.

Be it enacted by the People of the State of Maine as follows:

Sec. 1. 29-A MRSA §2054, sub-§2, ¶D, as enacted by PL 1993, c. 683, Pt. A, §2 and affected by Pt. B, §5, is amended to read:

D. Emergency lights used on a police vehicle; a Department of Corrections vehicle as described in subsection 1, paragraph B, subparagraph (6); a vehicle operated by a chief of police, a sheriff or a deputy sheriff; and a vehicle operated by a qualified deputy sheriff or other qualified individual performing court security-related functions and services must emit a blue light or a combination of blue and white light. ~~No other vehicle may be equipped with or display a blue light, except that on~~ On any vehicle, or replica of a vehicle, manufactured prior to 1952 and registered under section 457, the taillight may contain a blue or purple insert of not more than one inch in diameter.

Sec. 2. 29-A MRSA §2054, sub-§2, ¶F, as amended by PL 1995, c. 22, §1, is further amended to read:

F. Only vehicles listed in this paragraph, rural mail vehicles as provided in paragraph C, subparagraph (5) and school buses may be equipped with, display or use a red auxiliary or emergency light.

(1) Emergency lights used on an ambulance, an emergency medical service vehicle, a fire department vehicle, a fire vehicle or a hazardous material response vehicle must emit a red light or a combination of red and white light and may be equipped with one blue light mounted at the rear of the vehicle so that the light is visible to approaching traffic.

(2) The municipal officers or a municipal official designated by the municipal officers, with the approval of the fire chief, may authorize an active member of a municipal or volunteer fire department to use a flashing red signal light not more than 5 inches in diameter on a vehicle. The light may be displayed but may be used only while the member is en route to or at the scene of a fire or other emergency. The light must be mounted as near as practicable above the registration plate on the front of the vehicle or on the dashboard. A light mounted on the dashboard must be shielded so that the emitted light does not interfere with the operator's vision.

(3) Members of an emergency medical service licensed by Maine Emergency Medical Services may display and use

on a vehicle a flashing red signal light of the same proportion, in the same location and under the same conditions as those permitted municipal and volunteer firefighters, when authorized by the chief official of the emergency medical service.

SUMMARY

This bill allows a blue light to be mounted at the rear of authorized emergency vehicles.

STATE OF MAINE
121ST LEGISLATURE

LEGISLATIVE NOTICES

JOINT STANDING COMMITTEE ON TRANSPORTATION

Sen. Pamela H. Hatch, Senate Chair
Rep. Ronald E. Usher, House Chair

PUBLIC HEARING: Tuesday, February 25, 2003, 1:00 pm, Room 126 State House

(L.D. 464) Bill "An Act To Allow Fire and Emergency Medical Services Response Vehicles To Display One Blue Light at the Rear of the Vehicle" (H.P.0356) (Presented by Representative BULL of Freeport) (Cosponsored by Senator SAVAGE of Knox, Representative ANDREWS of York, Representative BUNKER JR. of Kossuth Township, Representative DUGAY of Cherryfield, Representative MARLEY of Portland, Representative MCNEIL of Rockland, Representative RINES of Wiscasset, Representative STONE of Berwick, Representative USHER of Westbrook)

(L.D. 493) Bill "An Act Regarding the Use of Lights and Sirens on Personal Vehicles Used by Volunteer Firefighters and Emergency Medical Services Personnel" (H.P.0382) (Presented by Representative GLYNN of South Portland)

(L.D. 518) Bill "Resolve, To Provide a Traffic Light in Naples" (H.P.0403) (Presented by Representative CRESSEY, JR. of Baldwin) (Cosponsored by Senator BENNETT of Oxford)

(L.D. 524) Bill "Resolve, To Have Signs Erected at the Town of Newburgh in Recognition of Ricky Craven" (H.P.0409) (Presented by Representative DUPREY of Hampden) (Cosponsored by Senator MITCHELL of Penobscot, Representative KAELIN of Winterport)

(L.D. 533) Bill "An Act To Add a Sign on Interstate 95 Indicating the Town of Bingham BY REQUEST" (S.P.0173) (Presented by Senator HATCH of Somerset) (Cosponsored by Representative MCGLOCKLIN of Embden)

(L.D. 506) Bill "An Act To Permit Municipalities To Erect Pedestrian Crossing Stop Signs in the Middle of the Road" (H.P.0391) (Presented by Representative CRESSEY, JR. of Baldwin) (Cosponsored by Senator SAVAGE of Knox, Representative COLLINS of Wells, Representative JODREY of Bethel, Representative MARLEY of Portland, Representative MARRACHE of Waterville, Representative MCKENNEY of Cumberland, Representative MCNEIL of Rockland, Representative PARADIS, JR. of Frenchville, Representative USHER of Westbrook)

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Augusta, ME 04333-0100
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TESTIMONY SIGN IN SHEET

COMMITTEE ON **TRANSPORTATION**

DATE: February 25, 2003

L.D.# or CONFIRMATION LD 464 An Act to Allow Fire and Emergency Medical Services Response Vehicles to Display One Blue Light at the Rear of the Vehicle

NAME	TOWN/AFFILIATION	PROPONENT	OPPONENT	NEITHER
1. Rep. Boyd Marley	Portland	✓		
2. Darrel Fournier	Freeport	✓		
3. [illegible] Manto	Pittston	X		
4. Glenn Dewitt	ME Fire. Ass			
5. Charles Bush	Old Town Fire Chief		✓	
6. Chris Grotton	MSP		✓	
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Maine State Federation of Fire Fighters
Legislative Memo

To: Joint Standing Committee on Transportation

RE: LD# :464 An Act To Allow Fire and Emergency Medical Services Response Vehicles To Display One Blue Light at the Rear of the Vehicle

Date: February 24, 2003

In an earlier memo I indicated that the legislative committee of the Maine State Federation of Fire Fighters opposed this bill. That was not correct. The Federation *supports* LD 464 because we agree with the Maine Fire Chiefs' Association that blue lights, combined with red lights make emergency vehicles more visible to oncoming traffic thereby increasing safety for emergency workers and approaching vehicles.

We urge you to pass LD 464.

SFR#13938

We need standardized warning light systems

Robert D. Aldrich, Fire Chief
Charles McKusick, Fire Fighter
Fridley Fire Department, Minnesota

SF- Emergency Lighting

When you talk with emergency vehicle operators, the conversation invariably turns to the need for warning light systems that are unique to emergency vehicles. Is it possible to develop guidelines from the technical studies that have already been conducted on emergency vehicle warning lights? When we evaluate these studies, we note that three important considerations emerge: (1) the color of lights, (2) the type of lights, and (3) their placement on the vehicle.

Color

Two notable studies at the University of Minnesota FIRE Center tested various colored lights. The 1973 California Highway Patrol "Blue Light Study" examined red and blue strobe lights, red and amber sealed beams, blue spotlights, and blue rotating beacons. The conclusion: the effect of different lights varies with the surrounding lighting conditions. In bright sunlight, the red strobe was most visible and most effective in reducing the speed of passing traffic. The blue strobe, however, caused the highest percentage of traffic to move into lanes away from the patrol vehicle.

In darkness, the blue strobe was most visible and most effective in reducing the speed of passing traffic. All light systems tested in darkness caused similar amounts of traffic to move into lanes away from the patrol vehicle. The Blue Light Study indicates that a combination of red and blue strobe warning lamps provides optimum warning.

A second study by the California Highway Patrol, the "Twinsonic® Light Study," measured the effect of Twinsonic light systems. The conclusion was that in daylight or darkness, the Twinsonic red and blue system was more effective than dual amber in moving traffic to lanes away from the patrol vehicle. However, dual amber lights consistently resulted in greater speed reduction.

Certain characteristics of red warning lights are noteworthy. Red is distinguishable at a greater distance than any other color and, in comparison to blue, is particularly arousing — possibly a learned reaction. But two-thirds of the population perceive red colored objects to be farther away than they actually are and, at low levels of illumination, reaction to red is slower than to blue.

These studies imply that no single color should serve as an emergency vehicle warning light. A red, blue, and amber system gives optimum results in vehicle detection, moving traffic to lanes away from the emergency vehicle and reducing the speed of traffic that is passing it.

Type of lights

The California Twinsonic Light Study compared Twinsonic red and blue with the types of lights tested earlier in the Blue Light Study. The results indicate that red and blue strobes do a better job of speed reduction than Twinsonic lights. The two were about equal in moving traffic away from the patrol vehicle.

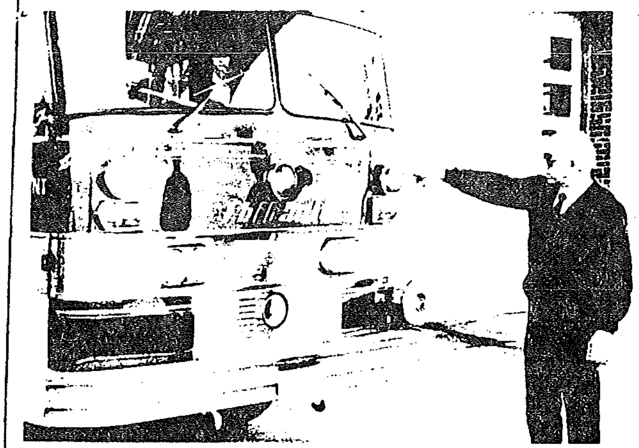
In contrast, the Department of Transportation study by Muhler and Berkhout,[1] which studied light configuration rather than color, found that in daylight conditions the strobe light compares unfavorably to sealed-beam lights, because of the strobe's brief peakout period (flash). The interesting point is that "distance thresholds" improve with slower light flashes. The two studies' results are not necessarily inconsistent. It appears that higher candlepower strobe flashes with blue and red colored globes are superior as attention and warning lights, while slower flash units may be superior in communicating the emergency vehicle's direction, distance, and rate of travel. This indicates that a combination of light types consisting of red and blue strobes and slower flash rotating or one-directional sealed-beam lights is most effective at getting attention, identifying the emergency vehicle's location, and indicating its rate and direction of travel.

Placement

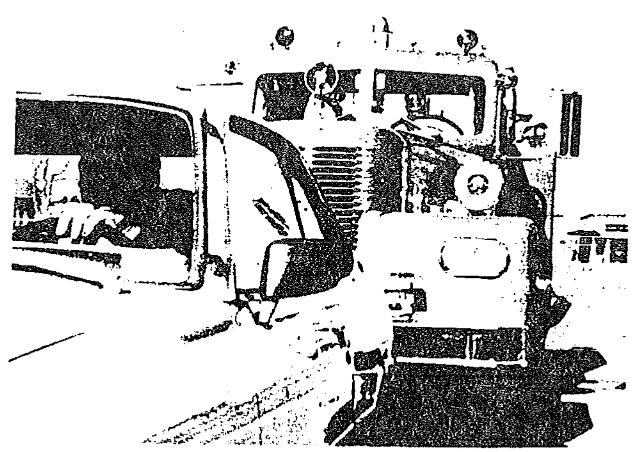
In positioning warning lights, one must consider the type of traffic that emergency vehicles encounter. In his article, "Emergency Vehicle Lights,"[2] John D. Rukavina noted, "Most emergency warning lights tend to be concentrated on the front of the apparatus cab roof." This means that motorists ahead of the emergency vehicle often are unable to see its warning lights, which poses a serious problem. Similarly, a serious situation exists if the emergency vehicle's sides are poorly illuminated. Emergency lighting must first draw the motorist's attention to the emergency vehicle entering an intersection at a right angle, and then inform the motorist of the rate and direction of travel. One type of emergency light does not accomplish all of these essential functions.

Emergency lighting importance

We have reached the limit of available noise production from mobile sirens; therefore, we place



Chief Robert Aldrich indicates the approximate height of an automobile's rear window in relation to this apparatus's red lights. The Triple 8 Mars center light and the sealed-beam lights at the sides provide optimum close proximity warning to motorists.



The popular compact cars of today accentuate the difficulty of seeing emergency vehicle warning lights when the emergency vehicle approaches from the rear.

greater reliance on emergency vehicle warning lights. Improved sound reduction design in today's automobile, coupled with competing sounds from stereos and air conditioners, makes it difficult to capture motorists' attention with sirens.

Shifting primary reliance to something other than emergency lights and sirens is obviously desirable. From 1962 to 1976, the St. Paul Fire Department, Minnesota, reduced emergency run accidents by 70 percent through the use of Opticom.[3] The New York City Fire Department significantly reduced accident rates by requiring emergency vehicles to stop before entering an intersection against a red light, a stop sign, or a yield sign.[4] But for most cities, Opticom is economically infeasible, and the New York procedure may be impractical for others. We continue to rely on our emergency warning lights.

Conclusions

We need a standardized system of emergency vehicle warning lights, and it should address type, color, and placement. The system should be unique to authorized emergency vehicles; its use by other vehicles should be prohibited. System requirements could be written as a performance standard to permit use of various manufacturers' approved warning light devices and to allow local agencies to use lamps tailored to their needs.

Researchers find that emergency warning lights must fulfill several functions. While these are expressed in various terms, they boil down to three essential functions: (1) drawing attention; (2) providing information on the vehicle's distance, and rate and direction of travel; and (3) eliciting a reaction from the motorist, *i.e.,* slow down and move into lanes away from the emergency vehicle. No single color or type of light provides superior performance of all these functions under all conditions; therefore, we need a *combination* of types and colors unique to emergency vehicles.

After reviewing the studies discussed in this article, we might suggest a system that addresses the following points:

1. Rapid flash rate, high intensity red and blue lamps which provide 360-degree visibility. (An example is the strobe light.) In daylight and darkness, the red-blue combination is most effective in moving traffic into lanes away from the emergency vehicle. The 360-degree visibility requirement necessitates placing lamps on the cab roof.

2. Slow flash rate, red and blue beams to convey the emergency vehicle's rate and direction of travel. As noted, recognition should be given to the problems inherent when the emergency vehicle approaches motorists from the rear or at right angles (*i.e.,* at intersections). It may be advisable to side-mount the slow flash rate lamps, or place them at grill level, since proximity and the rate and direction of travel are important when the emergency vehicle is approaching the motorist's vehicle.

3. In daylight, dual amber lights consistently evoked greater speed reduction than Twinsonic. The California Blue Light Study showed that in sunlight, the red strobe and in darkness, the blue were most effective in reducing the speed of passing traffic. When traffic is approaching the rear of a stopped emergency vehicle, particularly on four-lane highways, it is essential to reduce traffic speed. Roof-mounted red and blue strobes, or Twinsonic lights complemented by dual amber lights facing the rear, would effectively reduce the speed of traffic approaching from the rear. On two-lane highways, dual amber lights facing forward may be desirable to warn traffic approaching the front of the emergency vehicle.

Studies show that a red light by itself as an emergency vehicle warning light is inadequate. The thousands of accidents and hundreds of deaths that result from emergency vehicle accidents each year mandate research and development of a performance-oriented standardized emergency vehicle light system.

References

[1]"Detection Distance in Daylight of Roof-Mounted Emergency Vehicle Lights." *Journal of Safety Research.* Vol. 8, No. 2, June 1976, pp. 50-58. (Also see "Room for improvement in emergency lights." *Minnesota Fire Chief,* November-December 1977. Vol. 14, No. 2).

[2]*Minnesota Fire Chief,* November-December 1976, pp. 14 & 47.

[3]*Minnesota Fire Chief,* March-April 1978, pp. 16-17.

[4]*Minnesota Fire Chief,* November-December 1976, p. 47.

STATE OF MAINE
Department of Public Safety
18 Meadow Road
104 State House Station
Augusta, Maine
04333-0104

John Elias Baldacci
Governor

Michael F. Kelly
Commissioner

March 05, 2003

The following information is provided for your review in preparation for the work session on:

LD 464 – *An Act to Allow Fire and Emergency Medical Services Response Vehicles to Display One Blue Light at the Rear of the Vehicle.*

On February 25, 2003 I testified on behalf of the Maine State Police in opposition to this bill. We have several concerns about the effectiveness of this initiative. First and foremost, it is our overall goal to ensure the safety of our fellow professionals in the Fire and EMS services. We have enjoyed a positive relationship with these entities and share their concerns about scene safety and the safety of their personnel. Our position on this issue is not based on a desire to restrict them to anything less than the most effective warning systems available. It is our belief that this well-intentioned bill might produce very minimal benefit at best, and that the confusion and long term results of the legislation may outweigh any marginal benefit. I would like to briefly summarize our concerns here;

- We do not believe that the addition of a blue light to the rear of fire and EMS apparatus will increase safety or bring substantive changes in the driving behavior of the general public. In analyzing incidents where our marked cruisers are struck while parked at crash scenes, it is clear that blue lights do not make a substantive difference in driving behavior. In acknowledgment of this problem, legislation was enacted to require motorists to pull over into empty lanes of traffic whenever possible.
- We are concerned about the practice of essentially misleading motorists to believe that police are at a scene when this is not true. This misperception could result in unintended effects and the possible exposure of fire and EMS personnel to situations for which they are not prepared.
- There does not appear to be an identifiable trend toward the use of red and blue lights on all emergency vehicles. State laws and local ordinances vary throughout the country, but in speaking with fire apparatus manufacturers, emergency light distributors, and other New England State Police agencies, it appears that law enforcement *generally* utilizes blue or a combination of blue and amber lights, while EMS and fire apparatus *generally* display red or red, white, and amber lighting configurations. A leading distributor of Fire apparatus, Seagraves Inc related that they put blue lights on less than 2 % of the fire trucks sold throughout the country.

- Over the past few years, requests by non-law enforcement entities have been denied for blue or purple lights. MDOT, funeral directors, etc have opted to utilize amber or other colors to warn the public of their intentions. If this bill passes, it may well result in additional requests for blue lights. As with the current proposal before you, the next several requests may be just as well-intentioned, but may result in blue lights on DOT trucks, funeral vehicles, construction vehicles, etc. The eventual result may be similar to other warning signs or lighting, the public becomes so accustomed to seeing the blue lights that the desired reaction is lost.

Research results:

I spoke with Joseph Bader and Pat Hester of Federal Signal Corporation. Federal Signal Corp. manufactures and distributes emergency lights and sirens for public safety use. Mr. Bader sits on the SAE board and has participated in research relating to the effectiveness of various lights colors and types. The following information is a summary of the information from these interviews and various articles relating to the topic.

Although the issues relating to auxiliary warning equipment are quite varied, the research *generally* indicates the following;

- The type of light (strobe, halogen, etc), flash rate, installation position and height, etc are all important factors to consider along with color when determining effective warning light systems.
- Experts generally agree that a combination of colors and light types / styles are the most effective.
- The amount of light transmitted through the lens of an emergency light is maximized near the white/amber/yellow end of the spectrum.
- Generally, red light works best during daytime hours
- Generally, red and blue lights both perform well during nighttime hours.
- NFPA guidelines currently require an amber light to be installed at the rear of new fire / EMS apparatus.

Enclosures:

1. Requested survey results from New England State Police agencies
2. "Effective Warning Light Systems", by Andrew Smith
3. Article from the "Annals of Emergency Medicine", December 1991
4. Federal specification (KKK-A-1822E) for ambulances
5. Excerpt from NFPA guidelines (mirrors language from SAE standards)

Analysis of Emergency Vehicle Light usage in the New England States

02/27/03

This information was gathered through telephone calls to the State Police agencies in the respective states. It represents general guidelines for emergency vehicle lighting by service / profession in those states, but does not preclude some possible inconsistencies in specific jurisdictions.

I. **New Hampshire**	Law Enforcement displays blue lights Fire / EMS displays red light
Massachussetts	Majority of Law Enforcement agencies display blue and amber lights. Fire / EMS services generally display red, although some ambulances have a blue light on rear of chassis.
Vermont	Law Enforcement displays blue lights Fire / EMS displays red light
Rhode Island	Law Enforcement displays blue and red lights Fire / EMS displays red light
New York	Law Enforcement displays red and white lights Volunteer Firefighters display a blue light with a permit Fire / EMS apparatus display red, amber, and white lights
Connecticut	Law Enforcement displays blue and red lights Volunteer Firefighters display a blue light with a permit Ambulances display red and white lights Fire apparatus display red and white lights Volunteer EMS providers display green light(s)

EFFECTIVE WARNING LIGHT SYSTEMS

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

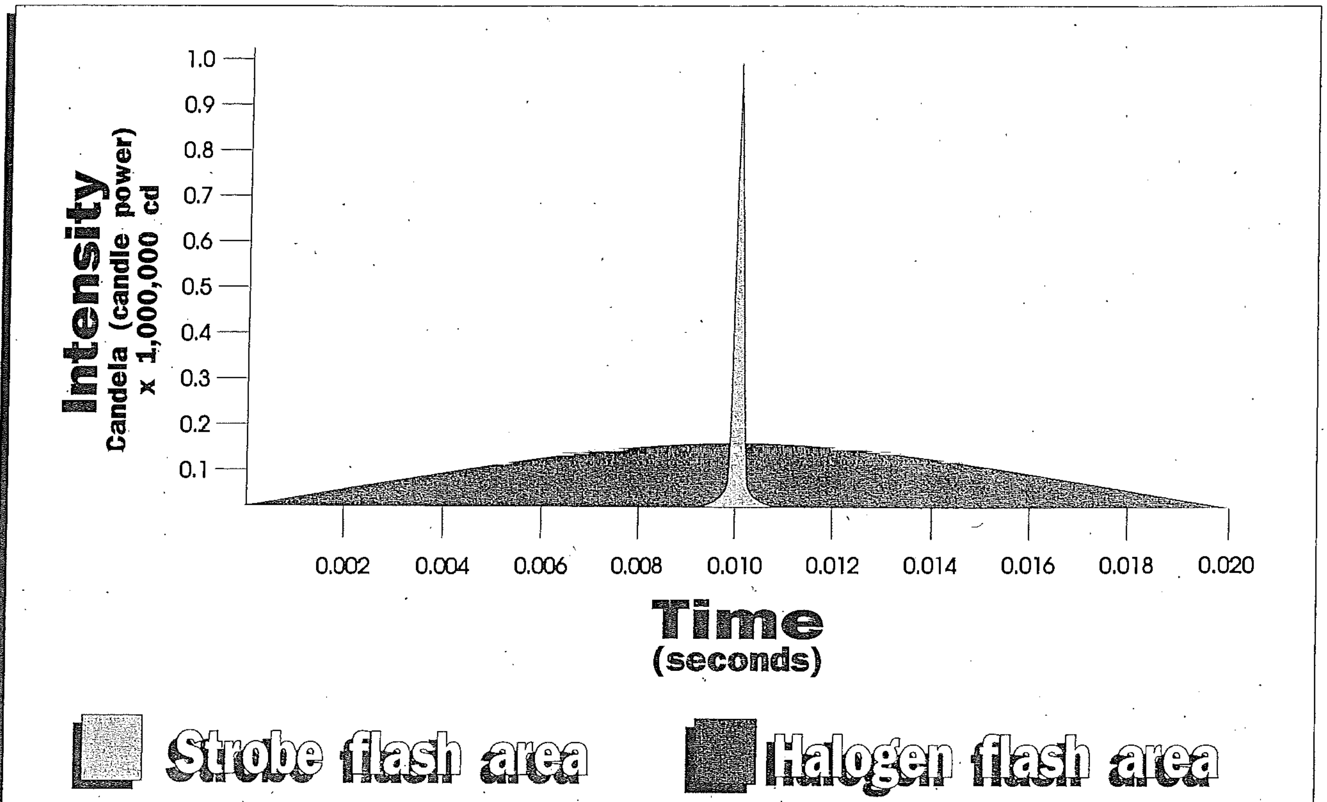


FIGURE 1

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™ 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 -

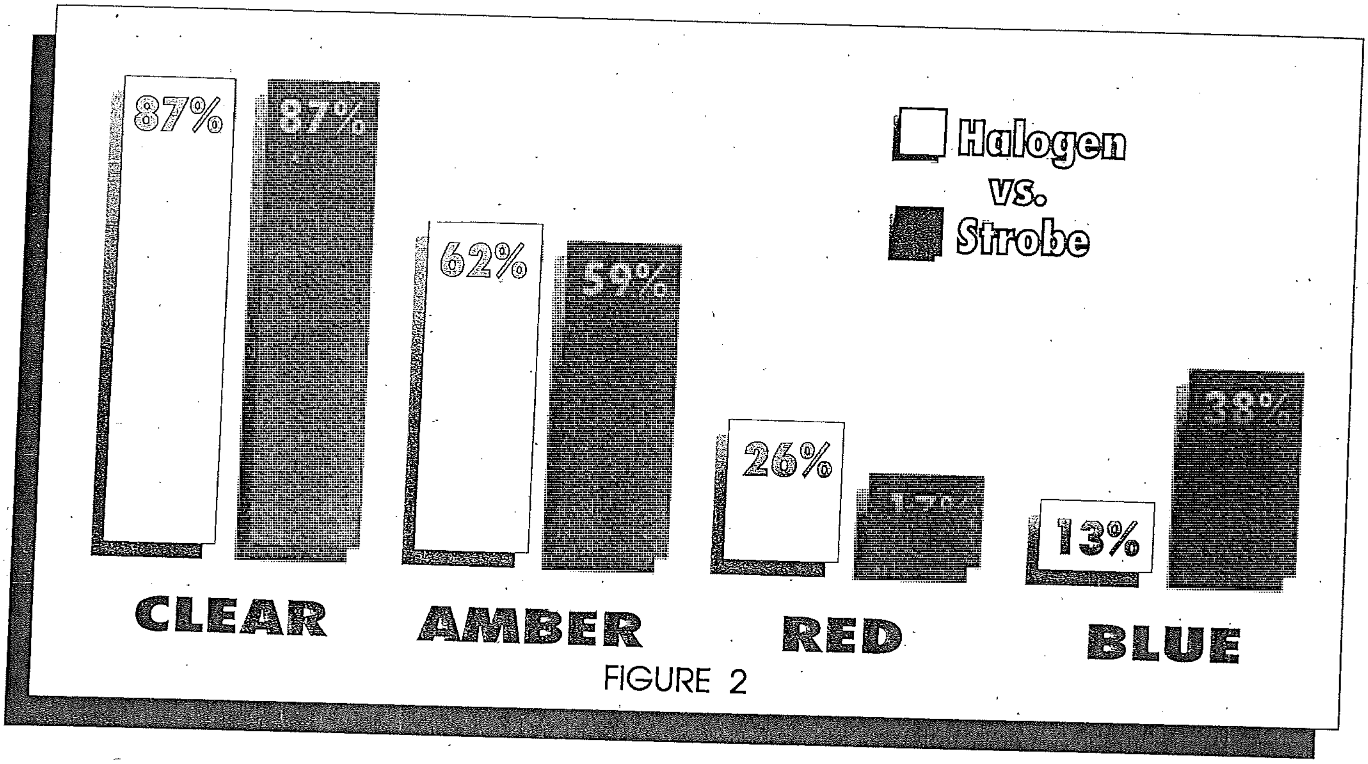


FIGURE 2

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 & reflecting 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

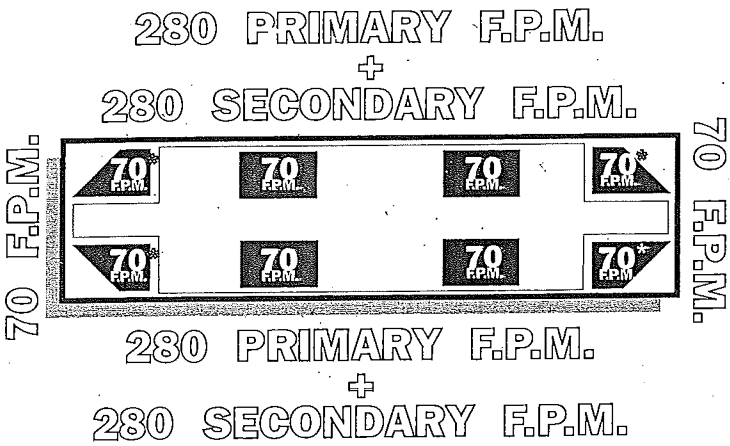
Blue signal "lost" in daylight.

Bulb life.

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

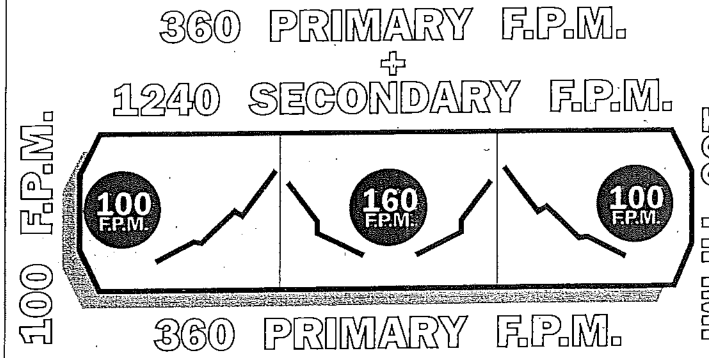
Fig. 4

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

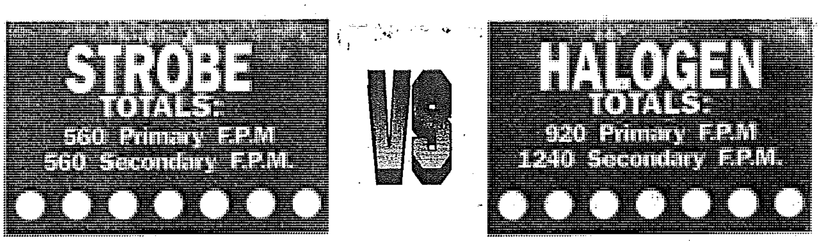


*End lamps must flash together to meet minimum SAE and California light output requirements.

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



The Results:



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.

search terms: Lights and siren, emergency vehicle warning systems, risk of collision, color combinations, strobe lights, traditional emergency vehicle colors, limited warning device, hearing loss, emergency medical services, ambulance collisions, emergency vehicles, audible and visible warning devices, collision prevention, greatest threat, safe and efficient responses, primary objectives of a warning system, attention, identification, proper reaction, emergency vehicle markings, collision risk reductions, visual warning systems, ambulance lighting standards, flashing lights, markings, audible warning systems, primary warning sense, Annals of Emergency Medicine, 1991, understanding of warning system characteristics, appropriate guidelines for prehospital transportation systems

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Lights and Siren: A Review of Emergency Vehicle Warning Systems

Emergency medical services providers routinely respond to emergencies using lights and siren. This practice is not without risk of collision. Audible and visual warning devices and vehicle markings are integral to efficient negotiation of traffic and reduction of collision risk. An understanding of warning system characteristics is necessary to implement appropriate guidelines for prehospital transportation systems. The pertinent literature on emergency vehicle warning systems is reviewed, with emphasis on potential health hazards associated with these techniques. Important findings inferred from the literature are 1) red flashing lights alone may not be as effective as other color combinations, 2) there are no data to support a seizure risk with strobe lights, 3) lime-yellow is probably superior to traditional emergency vehicle colors, 4) the siren is an extremely limited warning device, and 5) exposure to siren noise can cause hearing loss. Emergency physicians must ensure that emergency medical services transportation systems consider the pertinent literature on emergency vehicle warning systems.

Introduction

Emergency medical services (EMS) providers routinely respond to and from the scene of a medical emergency using lights and siren. This practice is not without risk, as numerous ambulance collisions have been reported, often with tragic outcome (1,2). Emergency vehicles are specifically painted, marked, and equipped with audible and visible warning devices to assist them as they negotiate traffic. Data suggest that intersections pose the greatest collision risk (1,2) and that emergency vehicles are more likely to be struck by another vehicle than vice versa (3). Therefore, the ability of another driver to detect and safely avoid an approaching emergency vehicle is crucial to collision prevention. A review of the literature, however, indicates that the physician-level emergency medicine literature has not adequately addressed this issue, although anecdotal and nonanalytical information on vehicle operations appears in the EMS, fire, and police service literature (1).

As medical director or medical control provider, the emergency physician has an important role in the development and implementation of EMS systems to include prehospital emergency vehicle operations (4,5). Many of the beliefs regarding emergency vehicle warning systems held by EMS personnel are based on anecdotes and unsupported data. State and local laws and rules regarding lights and sirens lack uniformity (6), and their origins may be traced to many years before modern research was conducted.

Motorists and pedestrians represent the greatest threat to safe and efficient responses by emergency vehicles. Assuming pedestrians and drivers understand their responsibilities to yield to emergency vehicles, the primary objectives of a warning system are gaining attention; identification; projecting size, distance, speed, and direction of travel; and obtaining a proper reaction (7). Emergency vehicle markings and warning devices must be evaluated against these factors when considering the potential for collision risk reduction.

This article reviews the pertinent biomedical and safety literature on emergency vehicle markings and warning techniques. The potential of these systems to prevent ambulance collisions is discussed. Special attention is given to the health hazards associated with these warning devices. Recommendations for current applications and future study are presented.

Visual Warning Systems

Lights

It is estimated that more than 90% of the sensory input to a motor vehicle driver is obtained visually (8). Thus, visual warning systems are likely to be crucial in alerting drivers to the approaching ambulance. Hills describes visibility, conspicuity, driver attention and field dependence, and driver expectancy as the factors determining whether an object is perceived appropriately (8). Visibility takes into account an object's visual size, luminance, color contrast (of object and background), and glare. Conspicuity refers to the amount of associated distractions (ie, camouflage). Unlike driver attention and expectancy, visibility and conspicuity must be considered in a warning technique's design because these factors are not highly dependent on driver behavior.

Federal guidelines provide for minimal ambulance lighting standards (9), but some controversy exists over the usefulness of these specifications (10). Furthermore, the federal specifications do not apply to other emergency vehicle types such as fire and resuce apparatus. Allen describes general considerations of light signal technique such as angle of visibility and mounting height (11), and detailed discussions of the topic are available from the federal government (12,13).

Flashing lights have been shown to be superior to steady signals in gaining attention, and this is generally accepted (14,15). Most but not all authorities believe that lights visible from the same side of the vehicle should flash in unison so as to "outline" the vehicle (6,7,10,11). However, Solomon cautions against the excessive use of lights visible from any one angle, suggesting that glare and dazzle may diminish visibility (10). Laboratory data lend support to this view, although no field studies are available (16). Flashing headlamps (high-beams) are frequent adjuncts to warning lights systems, although blinding oncoming drivers is a reported hazard (17).

The sensitivity of human vision peaks in the yellow-green portion of the spectrum. It is established that white is the most visible color for warning lights, followed by green, amber and red (18). White is effective in gaining attention but fails to identify the vehicle; it is therefore rarely used alone (7). Green is also visually effective but has similarly failed to gain widespread use because green is a "go," or "safe," color in our society (6). Yellow and red are colors that signify "danger," and this has led to their popularity as warning and caution identifiers. Yellow, at threshold levels, is often mistaken for a white flash (15). Red, too, has been criticized for being weakly visible (11), easily lost in tail lamps (7), and psychologically associated with rage and passion (10).

Combining colors to capitalize on both visibility and appropriate identification was examined by the California Highway Patrol in 1979 with promising results (19). This technique is frequently recommended (6,7,20); however, additional study on the optimal characteristics of a visible warning signal is needed.

Strobe rather than revolving-type incandescent lights have been criticized in the paraprofessional literature. One criticism is based on the brevity of strobes's powerful flash (20). A flash briefer than the 0.2-second visual-fixation speed could be missed (11). Other data suggest that most of a driver's visual field is not foveal, but rather peripheral (8), and therefore the initial attention-gaining effect of flashing lights would probably be independent of visual fixation. In addition, because brightness is a function of the time integral of luminous output (21), a strobe's high output would be expected to compensate its brief flash duration.

Muhler and Berkhout concluded that both strobe and incandescent lights had acceptable properties for emergency vehicle duty (22). Little objective data are available to suggest superiority of one light source over another.

Another more serious criticism of strobe lights is their suggested potential to trigger seizures in photosensitive patients (20,23,24). In fact, there are no reported cases in the physician-level medical literature; thus, the danger is not universally accepted (25). The concern appears to be based on the routine laboratory use of stroboscopic equipment to elicit seizures and EEG changes in certain individuals (23,25). Approximately 5% of the epileptic population is in some manner photosensitive (26). By far, the most common mechanism described is television-induced seizures, followed by seizures caused by sunlight and artificial lights (26).

The range of effective flash frequency for most patients is 6 to 40 Hz (26), which is far faster than typical emergency vehicle devices (25). In a recent series of 93 photosensitive patients, eight were reported to be sensitive to artificial light (in combination with or without sunlight), and none was reported to be sensitive to warning flashes (27).

EEG changes are commonly elicited by the stroboscope but are generally accepted to be without pathological consequence when induced in otherwise seizure-free individuals (27). They are not likely to affect driving (28), aircraft piloting (29), or other daily activities (30). Strobe lights appear to be no more likely to induce seizures than any similar flashing device (29,31). One reported effect of a strobe light on patient care was direct electrical interference with an ambulance ECG and did not involve the light output of the strobe (32).

Markings

The color and markings of an emergency vehicle are important elements in the ability of motorist to detect and identify the vehicle. Ambulances in particular are prone to confusion because the body configuration resembles that of commercial vehicles (33). The appropriate color for emergency vehicles has been discussed mostly in the fire service literature (34,35).

Solomon (36) has championed the cause for improving vehicle visibility and provides convincing arguments for the lime-yellow color seen on some emergency vehicles. In 1984, he reported a study of collision rates in nine large fire departments. Those using lime-yellow vehicles had less than half the number of collisions that departments with traditional red vehicles (35). Although key methods and statistical information were not reported, these findings are consistent with insurance studies demonstrating fewer automobile collisions in white and yellow cars (11).

Highway studies indicate that cream, yellow, and white objects are most visible (8,37). Acceptance of lime-yellow has become wide-spread; the Federal Aviation Administration (38), armed services fire apparatus, and approximately 50% of new fire service vehicles are painted in this color (34). In 1989, the American Optometric Assocation passed a resolution supporting the use of lime-yellow (36).

Federal specifications state that ambulances be painted white with a horizontal orange stripe and blue lettering (9) and are therefore infrequently painted lime-yellow. The National Research Council was largely responsible for the technical content of the original ambulance guidelines published in 1973 (39). However, Solomon reported that the council responded to the question of ambulance colors in 1972 by stating that "...the exterior color of the ambulance be primarily white with Omaha Orange trim..." and that "no special research or references supported the choice of Omaha Orange (10)." Nevertheless, this painting scheme was adopted as the standard.

State regulations generally do not embrace federal guidelines; thus, other painting schemes are frequently seen on nonfederal ambulances. The visibility and conspicuity of these various color combinations have not been evaluated systematically, although vehicle identification is probably diminished owing to nonstandard patterns and colors.

The multicolored ambulance, while distinctive (33), may suffer decreased conspicuity because of the effects of camouflage. Allen claimed that vehicles with two-tone paint patterns are likely to be less visible than single-colored vehicles (11). Hills commented that the decreased conspicuity of a multicolored vehicle is more evident in urban environments (8). Adequate field studies to assess this issue have not been conducted.

The blue "star of life" emblem is widely used and accepted in EMS (33). The National Highway Traffic Safety Administration recommends use of the emblem to improve EMS vehicle identification (40). Whether such emblems affect visibility is unknown, although vehicle identification may be enhanced. The use of retroreflective material to improve visibility at night is required for ambulances (9). Allen recommends that all emergency vehicles be outlined with this material (11). Incomplete coverage is discouraged because it may contribute to the camouflage effect.

Audible Warning Systems

Hearing is considered to be a primary warning sense. A loud auditory signal may exert an immediate arousing effect (42). Reaction time to a visual signal improved when an audible warning signal was included (43). Sirens and other audible warning devices have long been in use on emergency vehicles, and most state laws require their use during emergency runs (12). Federal specifications also require siren installation (9).

Recommended attributes of a warning signal include sufficient power and wide frequency spectrum to overcome making noise (41), rapid rise of pitch (7), and relatively rapid cycling time (44). The recommended frequency range is between 1 and 4 kHz (45), which is consistent with the peak sensitivity of human hearing. It is thought that high frequencies are not localizable (41), and sound energy below 1 kHz is wasted (44). Electromechanical sirens, now largely replaced by electronic devices, may not achieve an optimal power spectrum and suffer from inadequate sound penetration (46). Proper speaker placement appears important (46), and guidelines have been suggested (7).

To be effective, a siren signal must compete with the masking noise generated by the road, car radios, and ventilation fans and must overcome modern sound insulation techniques. A US Department of Transportation (DOT) report (44, 47) showed that over a siren's effective frequency range, the average signal attenuation (through closed-windowed automobile bodies combined with typical masking noise) resulted in a maximal siren effective distance of siren penetration of only 8 to 12 m at urban intersections. Only modest improvement in the situation occurred at suburban intersections and straight-ahead highway conditions. These findings have been corroborated (46,48), and from the data a maximum safe entry speed of 10 mph (15 km/hr) for intersections is recommended (49). The Department of Transportation report concluded that sirens will never become an effective warning device.

The use of different siren modes (eg, wail, yelp, high-low) has been controversial. One commentator recommends different modes for different traffic conditions (50), and some studies have suggested that the high-low European-style siren is less effective than other modes (7,51). However, two informative studies showed no significant differences between various siren modes (44,52). A national consensus committee and other have recommended the high-low siren as the most appropriate emergency vehicle signal (53,54). Efforts to identify the optimal siren signal are likely to achieve only marginal improvements, given the overall limited effectiveness of audible warning devices.

Air horns are frequent adjuncts to siren on larger emergency vehicles. However, little has been written on this warning device. Some suggest that the dual-trumpet air-powered horn is optimal (7), whereas others caution against drowning out the siren at a crucial time with a simultaneous air horn blast (55). The lack of published data precludes any firm conclusions being drawn on air horn effectiveness.

The Department of Transportation study notes that the sounds of sirens result in community annoyance and sleep disturbance but concluded that the risk of hearing damage to the general public was insignificant (44). However, a federal study has demonstrated sound levels exceeding occupational standards for the ambulance driver (56). Four studies have linked hearing loss to siren-exposed EMS personnel (57-60). Simple measures to reduce the risk of exposure include mounting the siren speakers on the front grill (rather than the cabin roof) and closing the windows (44). Patients and crew members in the rear compartment of the ambulance were considered to be at minimal risk of hearing loss (60). Studies to evaluate the long-term effectiveness of sound reduction measures are needed.

Summary

Based on the literature reviewed, the following conclusions can be drawn. First, there is evidence to suggest that red flashing lights alone may not be optimal visual signals. Combinations with other, more visible colors may improve overall lighting effectiveness. Further study to determine a flashing signal's optimal characteristics may be indicated.

Second, evidence supporting a seizure risk with strobe lights appears unsubstantiated.

Third, there is acceptance for the color lime-yellow on emergency vehicles, and this is supported by experimental and field studies. Red is less visible, white and orange ambulances may also be less visible, particularly in urban environments. A study comparing the visibility and collision rates of lime-yellow with those of traditional ambulance colors would be helpful.

Fourth, several studies clearly demonstrate that the siren is a severely limited warning device, effective only at very short ranges and very low speeds. Differences in siren mode do not appear to be important.

Last, hearing loss is siren-exposed EMS personnel has been documented. Steps to reduce the risk must be implemented.

Emergency physicians must ensure that EMS transportation planning and operations consider the pertinent literature on emergency vehicle warning systems. Efforts to inform EMS personnel of current knowledge on warning systems must be included in all primary and continuing education programs and become a integral part of risk management and safety training.

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FEDERAL SPECIFICATION FOR AMBULANCES KKK-A-1822E

Attached is the Federal Specification for the "Star-of-Life Ambulance," KKK-A-1822E, Dated June 1, 2002

This document supersedes KKK-A-1822D, dated November 1, 1994; and includes numerous changes intended to provide for a more reliable, functional, and safer ambulance. Further, this revision includes NOTES, NOTICES, and WARNINGS to inform purchasers of particularly important areas that can directly impact safety, reliability, and the ability of the ambulance to complete its mission.

PURCHASERS SHOULD CAREFULLY READ THIS SPECIFICATION PRIOR TO ORDERING AN AMBULANCE, AND SHOULD AVOID REQUIRING THE AMBULANCE MANUFACTURER TO SUPPLY EQUIPMENT OR DESIGNS THAT ARE CONTRARY TO THE REQUIREMENTS AND INTENT OF THIS SPECIFICATION.

3.7.9 DRIVER COMPARTMENT CONTROLS.

In addition to the left-hand drive controls and switches, the final stage ambulance manufacturer shall provide and locate, within easy normal reach of the driver, the specified controls and instruments. The battery switch (when furnished), and module disconnect switch or device (see 3.7.7.4) shall be different in feel from each other and be supplied with a handle or knob, which feels different to the touch than the other switches, or be physically isolated from them.

3.7.10 PATIENT COMPARTMENT CONTROLS.

Unless otherwise specified by the purchaser (see 6.2-t), the patient compartment controls, switches, and instruments shall be panel mounted and located within normal reach of the seated EMT (3.10.3).

3.7.11 MARKING OF SWITCHES, INDICATORS, AND CONTROL DEVICES.

All switches, indicators, and control devices supplied by the end product manufacturer of the ambulance shall be clearly visible to the ambulance personnel. They shall be perceptively and permanently identified with at least 12 point letters for the noun or function, and 8 point letters for the remainder of the legend. The identifications shall be contrasting colors etched or engraved in plastic or metal, or printed and laminated in see through plastic, and grouped according to function, and mounted in illuminated or backlit panel(s) or the console.

3.7.12 ELECTROMAGNETIC RADIATION AND SUPPRESSION.

In addition to OEM chassis, all added electrically operated or electrical generating devices, including alternators, air conditioning, warning light systems, electromagnetic coils of high current solenoids and relays, and medical equipment, shall be electromagnetic radiation suppressed, filtered, or shielded to prevent interference to radios and telemetry equipment aboard the vehicle and the surrounding area and shall not exceed SAE J551 limits. Type certification for these devices is acceptable. When specified by the purchaser (see 6.2-u), the completed ambulance vehicle shall be tested and certified to demonstrate that the RFI does not exceed the maximum limits of SAE J551. When specified by the purchaser, electrically operated medical equipment, both installed and portable, furnished shall comply to MIL-STD-461, Interface Standard Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment.

3.8 LIGHTING, EXTERIOR AND INTERIOR.

3.8.1 AMBULANCE EXTERIOR LIGHTING.

The basic exterior ambulance lighting shall comply to FMVSS No. 108 and the requirements herein, and include daytime running lights when standard from the chassis manufacturer, amber colored front and rear directional signals and hazard warning lights (except on Type II ambulances, if amber lenses are not available from OEM). The lower front and rear side marker lights shall flash in conjunction with the directional signals. Backup lights/loading light(s), clearance lamps (when applicable), ambulance emergency lights (3.8.2), floodlights (3.8.3), and spotlight(s) (3.8.4) (see Figures 1, 2, and 3), shall be furnished as specified. The ambulance manufacturer shall furnish light assemblies that are stainless steel, plastic, or other weather resistant materials, that are installed in a manner that will not cause electrolysis of light housings or vehicle body.

NOTE: TO MINIMIZE ELECTRICAL SYSTEM LOADING AND REDUCE MAINTENANCE, LIGHT EMITTING DIODE (LED) STOP/TAIL, DIRECTIONAL AND MARKER LIGHTS SHALL BE FURNISHED WHEN SPECIFIED BY THE PURCHASER, (SEE 6.2 - FFF) ON MODULAR BODIES.

3.8.2 AMBULANCE EMERGENCY LIGHTING.

As specified (see 6.2-v), a strobe, halogen, HID, LED, or any other source of light for the emergency lighting system shall provide the ambulance with 360 degrees of conspicuity for safety during its missions. The system shall display highly perceptible and attention-getting signals that function in a modal system, and convey the message in the "PRIMARY MODE" - "Clear the Right-of-Way" and in the "SECONDARY MODE" - "Hazard, Vehicle Stopped on Right-of-Way." The ambulance standard warning light system shall not impose a continuous average electrical load exceeding 40 amperes at 14.2 volts and 42 amperes with the optional second amber rear light.

WARNING: PURCHASERS SHOULD NOT SPECIFY WARNING LIGHTS BEYOND THOSE REQUIRED HEREIN. ADDITIONAL LIGHTING WILL UTILIZE RESERVE ALTERNATOR CAPACITY AND COULD RESULT IN OVER LOADED ELECTRICAL SYSTEMS. (SEE WARNINGS IN PARAGRAPHS 3.7.1. AND 3.7.6)

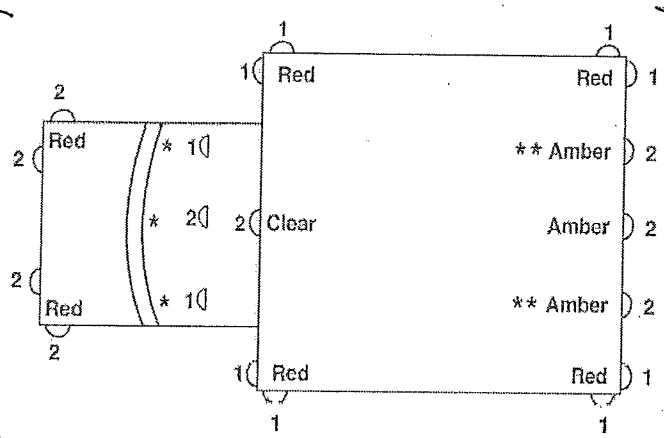
Additional warning lights are not required but, if specified (see 6.2-v), shall not obscure the light output of the standard warning light system. Additional warning light systems furnished shall be separately switched. Any warning devices furnished, in addition to the specified system, shall be compensated for with reserve or additional generating capacity as required in 3.7.6.

3.8.2.1 EMERGENCY LIGHTING SYSTEM CONFIGURATION.

The ambulance standard emergency warning light system shall contain twelve fixed red lights, one fixed clear light and one or two fixed amber or SAE "selective yellow" light(s), (see 6.2-v).

These lights shall function in a dual mode system as shown in Table I below and meet the physical and photometric requirements of 3.8.2.2. The upper body warning lights shall be mounted at the extreme upper corner areas of the ambulance body, below the horizontal roofline. The single clear light shall be centered between the two front facing, red, upper corner lights or in a dedicated housing mounted forward of the body on the cab roof (see Figures 1, 2, and 3). If due to limited body dimensions and physical size of the outboard forward facing lights, the lights may also be mounted in dedicated housings on the cab roof. The standard warning lights shall not be obstructed by doors or other ancillary equipment. The amber light(s) shall be symmetrically located between the two rear facing red lights. The red "grille" lights shall be located at least 76 cm (30 in.) above the ground and below the bottom edge of the windshield and be laterally separated by at least 46 cm (18 in.), measured from centerline to centerline of each lamp. The lateral facing intersection

TABLE 1



FLASH PATTERN

* Optional forward facing light locations on cab roof for two red and single center clear lights.

** Optional rear amber lights in lieu of single center light.

1 - Indicates lights flashing at the same time.
2 - Indicates lights flashing 180 degrees out of phase with 1.

MINIMUM FLASH ENERGY, Cd-S PER FLASH, PER FIXTURE				
COLOR	RED		CLEAR	AMBER
LOCATION	GRILL & FENDERS	UPPER BODY CORNERS	FRONT CENTER	REAR CENTER*
DAY	160 Cd-S @ HV	240 Cd-S @ HV	900 Cd-S @ HV	600 Cd-S @ HV
	80 Cd-S @ ± 5° H Points	120 Cd-S @ ± 5° H Points	450 Cd-S @ ± 5° H Points	300 Cd-S @ ± 5° H Points
	12 Cd-S @ All 5° V - 45° H Points	32 Cd-S @ All 5° V - 45° H Points	96 Cd-S @ All 5° V - 45° H Points	72 Cd-S @ All 5° V - 45° H Points
NIGHT	10 - 30% of the above			

* Single center rear or combined dual rear (Optional)

MODAL EMERGENCY LIGHTING SYSTEM				
COLOR & LOCATION / MODE OF OPERATION	RED	CLEAR	AMBER	RED
	Front and Rear Corners	Front Upper Center	Rear Center	Grille and Fender
PRIMARY "Clear the Right-of-Way"	ON	ON	ON	ON
SECONDARY "Hazard-Vehicle Stopped on Right-of-Way"	ON	OFF	ON	OFF

lights shall be mounted as close as possible to the front upper edge of each front fender and may be angled forward a maximum of 30 degrees. All warning lights furnished shall be mounted to project their highest intensity beams on the horizontal plane, (see 3.8.2.4).

3.8.2.2 PHOTOMETRIC, CHROMATICITY, AND PHYSICAL REQUIREMENTS.

Each emergency light shall flash 75 to 125 times per minute. The chromaticity values of the lights shall conform to SAE J578, for their respective color, except for the red lights, which in addition may conform to the following expanded boundary limits of: y =0.34; y = 0.32; x = 0.62. All warning lights shall project a beam spread of at least 5 degrees up and 5 degrees down and at least 45 degrees left and right of H-V. Each light shall produce flash energy, (Cd-s) per flash, measured from the H-V to all the extreme test point coordinates and shall be tested at all 5° increments. At no point shall the Cd-s values drop to less than the minimum values as shown in the table above when tested at 14.2 volts. Flash energy shall be determined in accordance with the SAE J845 method for determining the flash energy of a light. Testing shall be conducted on the device(s) as manufactured including use of the actual light source and all other related system components.

3.8.2.3 SWITCHING ARRANGEMENTS.

The emergency light switches shall be wired and arranged to provide the warning light signal modes and combinations as specified. All emergency light switches shall be labeled (see 3.7.11) and each Primary/Secondary mode switch shall have an amber or red indicator light to show the driver which mode is activated. When strobe lights are furnished or, when specified (see 6.2-v) for incandescent lights, a day-night switch shall be provided. When specified (see 6.2-v) from the lighting system manufacturer, an automatic switch to the "Secondary Mode" when the gear selector is placed in the "Park/ Neutral" position, with a manual override to the "Primary Mode" shall be furnished. Additionally, when specified (see 6.2-v) from the lighting system manufacturer, the lighting system shall provide an ambient light sensing circuit to automatically switch to the "Night" position while in the "Secondary Mode". A manual override to the daytime (bright) mode shall be provided. Operators manual (3.20) shall include suggestive management instructions for the warning systems.

3.8.2.4 HARDWARE CONSTRUCTION AND INSTALLATION.

The emergency lighting system shall be comprised of components and devices that comply to the general requirements and tests of SAE J575g, J576d, J578, and J551, as applicable for the unit. Warning lights shall be firmly fastened to reinforced body surfaces in accordance with the lighting manufacturer's requirements and recommendations and include aiming wedges to compensate for sloped body surfaces, grill, hood and fender angles or mold release angles on roof caps. The ambulance manufacturer shall aim the lights to assure that all lighting performance requirements herein are met. The lights shall be aimed either mechanically or optically on the horizontal axis with a tolerance of +0 degrees to -3 degrees. All switches, connectors, and wiring shall be rated to carry a minimum of 125 percent of their maximum ampere load. When halogen or other long duty cycle light source is used, the duty cycle of any device shall not exceed 50 percent. When strobe lights are furnished, all high voltage leads and connections shall be insulated and enclosed, or weather proof connectors, with the proper voltage rating shall be used.

11-3 Power Supply.

11-3.1* A 12-volt or 24-volt electrical alternator shall be provided. It shall have a minimum output at idle to meet the minimum continuous electrical load of the apparatus as defined in 11-3.2, at 200°F (93°C) ambient temperature within the engine compartment, and shall be provided with full automatic regulation.

11-3.2 The minimum continuous electrical load shall consist of the total amperage required to simultaneously operate the following in a stationary mode during emergency operations:

(a) The propulsion engine and transmission

(b) All clearance and marker lights, headlights, and other electrical devices mandated by the Federal Motor Vehicle Safety Standard (FMVSS) No. 108, "Lamps, reflective devices, and associated equipment," and other laws or regulations

(c) The radio(s) at a duty cycle of 10 percent transmit and 90 percent receive. For calculation and testing purposes, a default value of 5 amps continuous shall be used.

(d) The lighting necessary to produce 1 footcandle (11 lx) of illumination on all walking surfaces on the apparatus and on the ground at all egress points onto and off the apparatus, 5 footcandles (54 lx) of illumination on all control and instrument panels, and 50 percent of the total compartment lighting loads

(e) The minimum optical warning system required in Section 11-8, where the apparatus is blocking the right-of-way

(f) The continuous electrical current required to simultaneously operate any fire pumps, aerial devices, and hydraulic pumps

(g) *Other warning devices and electrical loads defined by the purchaser as critical to the mission of the apparatus

11-3.3* The condition of the low-voltage electrical system shall be monitored by a system that provides an audible and visual warning to persons on, in, or near the apparatus of an impending electrical system failure caused by the excessive discharge of the battery set. The charge status of the battery shall be determined either by direct measurement of the battery charge or indirectly by monitoring the system voltage. If system voltage is monitored, the alarm shall sound if the system voltage at the battery or at the master load disconnect switch drops below 11.8 volts for 12-volt nominal systems or 23.6 volts for 24-volt nominal systems for more than 120 seconds.

11-3.4 A voltmeter shall be mounted on the driver's instrument panel to allow direct observation of the system voltage.

11-3.5 Load Management.

11-3.5.1* If the total connected electrical load exceeds the minimum continuous electrical output rating of the installed alternator(s) operating under the conditions specified in 11-3.1, an automatic electrical load management system shall be required.

11-3.5.2 The minimum continuous electrical loads defined in 11-3.2 shall not be subject to automatic load management.

11-4* Batteries.

11-4.1 Batteries shall be of the high-cycle type.

11-4.2 The battery system shall be able to restart the engine after providing the minimum continuous electrical load for at least 10 minutes with the engine off. The minimum continuous electrical load shall not discharge the battery system by more than 50 percent of the reserve capacity rating during the 10-minute period.

11-4.3 The battery system CCA rating shall meet or exceed the minimum CCA recommendations of the engine manufacturer.

11-4.4 The batteries shall be mounted to prevent movement during apparatus operation and shall be protected against road spray.

11-4.4.1 The batteries shall be readily accessible for examination, test, and maintenance.

11-4.4.2* Where an enclosed battery compartment is provided, it shall be ventilated to the exterior to prevent the buildup of heat and explosive fumes. The batteries shall also be protected against vibration and temperatures that exceed the battery manufacturer's recommendation.

11-4.5* An onboard battery conditioner or charger, or a polarized inlet, shall be provided for charging all batteries. Where an onboard conditioner or charger is supplied, the associated line voltage electrical power system shall be installed in accordance with Chapter 21.

11-4.6 A master load disconnect switch shall be provided between the starter solenoid(s) and the remainder of the electrical loads on the apparatus. The batteries shall be connected directly to the starter solenoid(s). Electronic control systems and similar devices shall be permitted to be otherwise connected if so specified by their manufacturer.

11-4.6.1 The alternator shall be wired directly to the batteries through the ammeter shunt(s), if one is provided, and not through the master load disconnect switch.

11-4.6.2* A green "battery on" pilot light that is visible from the driver's position shall be provided.

11-4.7 To minimize the load placed on the electrical system during apparatus start-up for an emergency response, a sequential switching device shall be permitted to energize the optical warning devices required in 11-3.2 and other high-current devices. Where incorporated, the switching device shall first energize the electrical devices required in 11-3.2 within 5 seconds.

11-5 Starting Device.

11-5.1 An electrical starting device shall be provided for the engine.

11-5.2 Where the electrical starting device is operating under maximum load, the voltage drop of the conductors between the battery and the starting device shall be in accordance with SAE J541, *Voltage Drop for Starting Motor Circuits*.

11-6 Temperature Exposure. Any alternator, electrical starting device, ignition wiring, distributor, or ignition coil shall be moisture resistant and protected such that it is not exposed to a temperature that exceeds the component manufacturer's recommendations.

11-7* Electromagnetic Interference. Electromagnetic interference suppression shall be provided, as required, to satisfy the radiation limits specified in SAE J551-2, *Test Limits and Methods of Measurement of Radio Disturbance Characteristics of Vehicles, Motorboats, and Spark-Ignited Engine-Driven Devices*. The purchaser shall indicate if testing and certification under SAE J551-2 is required.

11-8 Optical Warning Devices. Each apparatus shall have a system of optical warning devices that meets or exceeds the requirements of this section.

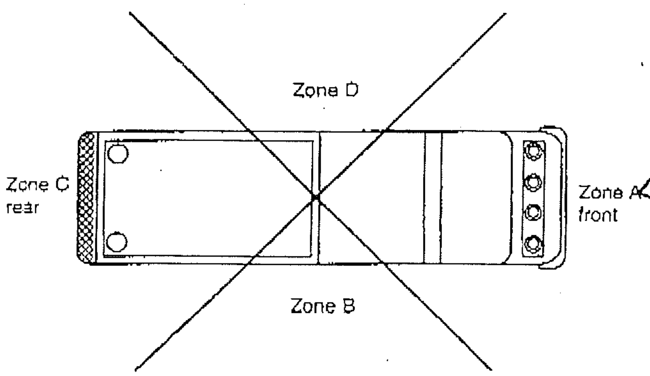
11-8.1* The optical warning system shall consist of an upper and lower warning level. The requirements for each level shall be met by the warning devices in that particular level without consideration of the warning devices in the other level.

11-8.2 For the purpose of defining and measuring the required optical performance, the upper and lower warning levels shall each be divided into four warning zones. The four zones shall be determined by drawing lines through the geometric center of the apparatus at 45 degrees to a line lengthwise of the apparatus through the geometric center. The four zones shall be designated A, B, C, and D in a clockwise direction with zone A to the front of the apparatus. *(See Figure 11-8.2.)*

11-8.3 Each optical warning device shall be installed on the apparatus and connected to the apparatus's electrical system in accordance with the requirements of this standard and the requirements of the manufacturer of the device.

11-8.4 A master optical warning device switch that energizes all of the optical warning devices shall be provided.

Figure 11-8.2 Warning zones for optical warning devices.



11-8.5 The optical warning system on the fire apparatus shall be capable of two separate signaling modes during emergency operations. One mode shall signal to drivers and pedestrians that the apparatus is responding to an emergency and is calling for the right-of-way. The other mode shall signal that the apparatus is stopped and is blocking the right-of-way.

11-8.6* A switching system shall be provided that senses the position of the parking brake or the park position of an automatic transmission. When the master optical warning system switch is closed and the parking brake is released or the automatic transmission is not in park, the warning devices signaling the call for the right-of-way shall be energized. When the master optical warning system switch is closed and the parking brake is on or the automatic transmission is in park, the warning devices signaling the blockage of the right-of-way shall be energized. The system shall be permitted to have a method of modifying the two signaling modes.

11-8.7 The optical warning devices shall be constructed or arranged so as to avoid the projection of light, either directly or through mirrors, into any driving or crew compartment(s).

11-8.8 The front optical warning devices shall be placed so as to maintain the maximum possible separation from the headlights.

11-8.9 The optical sources on each level shall be of sufficient number and arranged so that failure of a single optical source does not create a measurement point, in any zone on the same level as the failed optical source, without a warning signal at a distance of 100 ft (30 m) from the geometric center of the apparatus.

11-8.10* **Flash Rate.**

11-8.10.1 The minimum flash rate of any optical source shall be 75 flashes per minute, and the minimum number of flashes at any measurement point shall be 150 flashes per minute.

Steady burning nonflashing optical sources shall be permitted to be used. The optical energy provided by these nonflashing optical sources shall not be included in the calculations of the zone's total optical power.

11-8.10.2 The flasher of any current-interrupted flashing device shall otherwise meet the requirements of SAE J1054, *Warning Lamp Alternating Flashers*.

11-8.11* Permissible colors or combinations of colors in each zone, within the constraints imposed by applicable laws and regulations, shall be as shown in Table 11-8.11. All colors shall be as specified in SAE J578, *Color Specification*, for white, red, yellow, or blue.

Table 11-8.11 Zone Colors

Color	Calling for Right-of-Way	Blocking Right-of-Way
Red	Any zone	Any zone
Blue	Any zone	Any zone
Yellow	Any zone except A	Any zone
White	Any zone except C	Not permitted

11-8.12* **Requirements for Large Apparatus.** If the apparatus has a bumper-to-bumper length of 22 ft (6.7 m) or more or has an optical center on any optical warning device greater than 8 ft (2.4 m) above level ground, the requirements of 11-8.12.1 through 11-8.12.5 shall apply.

11-8.12.1 The upper-level optical warning devices shall be mounted as high and as close to the corner points of the apparatus as is practical in order to define the clearance lines of the apparatus. However, these optical warning devices shall not be mounted above the maximum height, specified by the device manufacturer, that gives an intensity value at 4 ft (1.2 m) above level ground and 100 ft (30.5 m) from the optical warning device of less than 50 percent of that required at the optical center.

11-8.12.2 In order to define the clearance lines of the apparatus, the optical center of the lower-level optical warning devices in the front of the vehicle shall be mounted forward of the front axle centerline and as close to the front corner points of the apparatus as is practical. The optical center of the lower-level optical warning devices at the rear of the vehicle shall be mounted behind the rear axle centerline and as close to the rear corners of the apparatus as is practical. The optical center of any lower-level device shall be between 18 in. and 62 in. (457 mm and 1575 mm) above level ground.

11-8.12.3* A midship optical warning device shall be mounted on both the right and left sides of the apparatus with the optical center of the device at a distance between 18 in. and 62 in. (457 mm and 1575 mm) above level ground if the distance between the front and rear lower-level optical devices exceeds 25 ft (7.6 m) at the optical center. Additional midship optical warning devices shall be required, where necessary, to maintain a horizontal distance between the centers of adjacent lower-level optical warning devices of 25 ft (7.6 m) or less.

Table 11-8.12.4 Minimum Optical Power Requirements for Large Apparatus

		Mode of Operation					
		Clearing Right-of-Way			Blocking Right-of-Way		
Zone	Level	H	At Any H Point	At Any Point 5 Degrees Up or 5 Degrees Down from H	H	At Any H Point	At Any Point 5 Degrees Up or 5 Degrees Down from H
A	Upper	1,000,000	10,000	3,500	400,000	10,000	3,500
B	Upper	400,000	10,000	3,500	400,000	10,000	3,500
C	Upper	400,000	10,000	3,500	800,000	10,000	3,500
D	Upper	400,000	10,000	3,500	400,000	10,000	3,500
A	Lower	150,000	3,750	1,300	150,000	3,750	1,300
B	Lower	150,000	3,750	1,300	150,000	3,750	1,300
C	Lower	150,000	3,750	1,300	150,000	3,750	1,300
D	Lower	150,000	3,750	1,300	150,000	3,750	1,300

Note: All values are in candela-seconds/minute.
H = Horizontal plane passing through the optical center.

11-8.12.4* For each operating mode, the combined optical power of all the optical sources shall meet or exceed the zone total optical power requirements shown in Table 11-8.12.4.

11-8.12.5 No individual measurement point shall be less than that shown in Table 11-8.12.4.

11-8.13* **Requirements for Small Apparatus.** If the apparatus has a bumper-to-bumper length of less than 22 ft (6.7 m) and has the optical center of all optical warning devices at 8 ft (2.4 m) or less above level ground, the requirements of 11-8.13.1 through 11-8.13.4 shall apply.

11-8.13.1 The upper-level optical warning devices shall be mounted as high as practical, but not over 8 ft (2.4 m), at the optical center. They shall be permitted to be combined in one or more enclosures and shall be permitted to be mounted on the cab roof or any other convenient point.

11-8.13.2 One or more lower-level optical warning devices shall be mounted as close as practical to each front corner of the apparatus with the optical center of the device at a distance between 18 in. and 48 in. (457 mm and 1220 mm) above level ground.

11-8.13.3 For each operating mode, the combined optical power of all the optical sources mounted on both the upper and lower levels shall meet or exceed the zone's total optical power requirements shown in Table 11-8.13.3.

11-8.13.4 No individual measurement point shall be less than that shown in Table 11-8.13.3.

Table 11-8.13.3 Minimum Optical Power Requirements for Small Apparatus

	Mode of Operation					
	Clearing Right-of-Way			Blocking Right-of-Way		
Zone	H	At Any H Point	At Any Point 5 Degrees Up or 5 Degrees Down from H	H	At Any H Point	At Any Point 5 Degrees Up or 5 Degrees Down from H
A	1,000,000	10,000	3,500	400,000	10,000	3,500
B	200,000	8,000	3,500	200,000	10,000	3,500
C	400,000	10,000	3,500	800,000	10,000	3,500
D	200,000	8,000	3,500	200,000	10,000	3,500

Note: All values are in candela-seconds/minute.
H = Horizontal plane passing through the optical center.

11-8.14 Tests of Optical Warning Devices.

11-8.14.1 **Mechanical and Environmental Test.** All optical warning devices including those tested under SAE J595, *Flashing Warning Lamps for Authorized Emergency, Maintenance, and Service Vehicles*, and SAE J1318, *Gaseous Discharge Warning Lamp for Authorized Emergency, Maintenance, and Service Vehicles*, shall be tested in conformance with SAE J845, *360 Degree Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles*. All devices shall comply with the following performance requirements of that standard:

(1) Vibration
(2) Moisture
(3) Dust
(4) Corrosion
(5) High temperature
(6) Low temperature
(7) Durability
(8) Warpage

Exception: Optical devices and components designed for mounting only in weatherproof, interior spaces shall be required to comply only with the vibration test and the warpage test for plastic components.

11-8.14.2 **Photometric Test Procedures for Optical Devices.** Testing shall be performed by, or on behalf of, the device manufacturer to ensure compliance with the requirements of 11-8.14.2.1 through 11-8.14.2.4. The results of the testing shall be used by the apparatus builder or purchaser to determine compliance with this standard. The goniometer, integrating photometer, and other equipment used to take the test measurements shall meet the requirements of SAE J1330, *Photometry Laboratory Accuracy Guidelines.*

11-8.14.2.1 The optical source shall be mounted in a goniometer and operated as it would be in a normal system application. The minimum distance between the light emitting surface of the source being tested and the front face of the photometer detector shall be 59 ft (18 m). The goniometer shall be oriented and the integrating photometer shall be set to integrate light pulses from the source for 20 seconds.

11-8.14.2.2 For all tests performed with the power applied, the lighting system, or component thereof, shall be operated at 12.8 volts ±0.1 volt for 12-volt rated equipment and 25.6 volts ±0.2 volt for 24-volt rated equipment measured at the point of entry into the component. If the equipment is rated for operation on both 12 volts and 24 volts, the tests shall be performed at both voltages.

11-8.14.2.3 The technique described in 11-8.14.2.1 shall be performed along the horizontal plane that passes through the optical center beginning at the optical center and repeated at 5-degree intervals to the left and right of the optical center throughout the active horizontal angle of light emission of the optical source.

11-8.14.2.4 Measurements shall be repeated at 5 degrees up and 5 degrees down from the horizontal plane that passes through the optical center beginning at a point on a line passing through the optical center and perpendicular to the horizontal plane and passing through the optical center. The measurements shall be repeated at 5-degree intervals to the left and right of this line throughout the active horizontal angle of light emission of the optical source. If the optical warning device contains more than one optical source, the test shall be repeated for each optical source.

11-8.15* Certification of Compliance. The apparatus manufacturer shall be permitted to demonstrate compliance of the warning system by one of the following methods:

(a) Certification that the system was installed within the geometric parameters specified by the manufacturer of the system and referencing the optical source test reports provided by the manufacturer of the system.

(b) Certification that a mathematical calculation performed by a qualified person demonstrates that the combination of individual devices as installed meets the requirements of this standard. This calculation shall be based on test reports for individual optical sources provided by the manufacturer of the device.

(c) Actual measurement of the lighting system after installation on the apparatus.

11-9 Audible Warning Devices.

11-9.1* Audible warning equipment in the form of at least one automotive traffic horn and one electric or electronic siren shall be provided. The siren manufacturer shall certify the siren as meeting the requirements of SAE J1849, *Emergency Vehicle Sirens.* A means shall be provided to allow the activation of the siren within convenient reach of the driver.

11-9.2 Where furnished, air horns, electric siren(s), and electronic siren speaker(s) shall be mounted as low and as far forward on the apparatus as practical. Audible warning equipment shall not be mounted on the roof of the apparatus.

11-10 Work Lighting.

11-10.1 The work area immediately behind the vehicle shall be illuminated to a level of at least 3 footcandles (33 lx) within a 10 ft × 10 ft (3 m × 3 m) square to the rear of the vehicle. If a hose bed is provided, lighting on this hose bed shall be at a level of 3 footcandles (33 lx) or higher. Lateral hose beds (crosslays) that are permanently covered shall not be required to be illuminated.

11-10.2 The apparatus shall be equipped with lighting that is capable of providing illumination at a minimum level of 1 footcandle (11 lx) on ground areas within 30 in. (762 mm) of the edge of the apparatus in areas designed for personnel to climb onto the apparatus or descend from the apparatus to the ground level. Lighting designed to provide illumination on areas under the driver and crew riding area exits shall be activated automatically when the exit doors are opened. All other ground area lighting shall be switchable.

11-10.3 Apparatus shall have sufficient lighting to provide an average minimum level of 1 footcandle (11 lx) in the crew compartment(s); the engine compartment; the pump compartment; and each enclosed tool and equipment compartment greater than 4 ft^3 (0.11 m^3) in volume and having an opening greater than 144 in.^{2} (92,900 mm^2); as well as on all work areas, steps, and walkways.

11-10.4 Switches for all work lighting shall be readily accessible. The lights shall be arranged to minimize accidental breakage.

11-11 Hazard Light. A red flashing or rotating light, located in the driving compartment, shall be illuminated automatically whenever the apparatus's parking brake is not fully engaged and any of the following conditions exist:

(1) Any passenger or equipment compartment door is open
(2) Any ladder or equipment rack is not in the stowed position
(3) Stabilizer system not in its stowed position
(4) Powered light tower is extended
(5) Any other device is opened, extended, or deployed that creates a hazard or is likely to cause damage to the apparatus if the apparatus is moved

The light shall be marked with a sign that reads: "Do Not Move Apparatus When Light Is On."

11-12 Backup Alarm. An electric or electronic backup alarm shall be provided that meets the Type D (87 dBA) requirements of SAE J994, *Alarm — Backup — Electric, Laboratory Performance Testing.*

11-13 Stop, Tail, and Directional Lights. The apparatus shall be equipped with all stop, tail, and directional lights required by the Federal Motor Vehicle Safety Standard (FMVSS) No. 108, "Lamps, reflective devices, and associated equipment." Equipment shall be mounted so that it will not obscure the rear stop, tail, and directional lights. Directional lights shall be visible from the front, sides, and rear of the apparatus. On apparatus 30 ft (10 m) or longer in length, a turn signal shall be mounted approximately midway along the apparatus at approximately running board height.

11-14 Electrical System Performance Tests.

11-14.1* The apparatus low-voltage electrical system shall be tested and certified. The certification shall be delivered to the purchaser with the apparatus.

TESTIMONY OF LT. CHRISTOPHER GROTTON
MAINE STATE POLICE

(In Opposition to) L.D. 464

An Act to Allow Fire and Emergency Medical Services Response Vehicles to Display One Blue Light at the Rear of the Vehicle

Before the Joint Standing Committee on Transportation

Presented by Representative Bull

Hearing: February 25, 2003 at 1:00 p.m. in Rm 126, Statehouse

SENATOR HATCH, REPRESENTATIVE USHER, AND MEMBERS OF THE JOINT STANDING COMMITTEE ON TRANSPORTATION, MY NAME IS LT. CHRISTOPHER GROTTON. I AM HERE TO REPRESENT THE MAINE STATE POLICE AND TESTIFY IN OPPOSITION TO L.D. 464.

UNDER CURRENT MAINE LAW, THE COLOR OF LIGHTS DISPLAYED BY EMERGENCY VEHICLES IS CLEARLY DELINEATED. LAW ENFORCEMENT VEHICLES DISPLAY BLUE AND WHITE LIGHTS, WHILE FIRE AND EMS VEHICLES DISPLAY RED OR WHITE LIGHTS. WHEN A MOTORIST OBSERVES EMERGENCY LIGHTS ON A ROADWAY IN THE STATE OF MAINE, THE TYPE OF VEHICLE AND THE MISSION OF THE OPERATOR ARE CLEARLY UNDERSTOOD.

IT IS OUR BELIEF THAT THE ADDITION OF A BLUE LIGHT ON THE REAR OF FIRE AND EMS APPARATUS WOULD PROVIDE LITTLE IF ANY SAFETY BENEFIT TO RESPONDING PERSONNEL. IT HAS BEEN OUR EXPERIENCE THAT MOTORISTS DO NOT ALWAYS REACT APPROPRIATELY BY REDUCING THEIR SPEED OR CHANGING LANES WHEN APPROACHING

BLUE LIGHTS ON LAW ENFORCEMENT VEHICLES. TO ADDRESS THIS ISSUE, LEGISLATION WAS RECENTLY ENACTED TO REQUIRE MOTORISTS TO MOVE TO ADJACENT, UNOCCUPIED LANES OF TRAVEL WHEN APPROACHING A POLICE CRUISER DISPLAYING EMERGENCY LIGHTS. THE VARIETY OF INCIDENTS THAT REQUIRE LAW ENFORCEMENT RESPONSE CAN ACTUALLY TEND TO ATTRACT AN EXTRA MEASURE OF PUBLIC INTEREST, CREATING TRAFFIC CONGESTION WHICH IS COUNTER PRODUCTIVE TO SCENE SAFETY. DESPITE OUR CONSTANT EFFORTS TO ENHANCE VISIBILITY AT SCENES BY ADDING AND IMPROVING EMERGENCY LIGHTING, OUR CRUISERS ARE STRUCK WITH ALARMING REGULARITY. OVER THE PAST 2 YEARS, MAINE STATE POLICE CRUISERS HAVE BEEN STRUCK 8 TIMES WHILE PARKED AT ACCIDENT OR CRIME SCENES AND DISPLAYING EMERGENCY LIGHTS. THE MOST RECENT INCIDENT OCCURRED ONLY A FEW WEEKS AGO, WHEN A TROOPER WAS INJURED AND A CRUISER TOTALLED WHEN HE WAS STRUCK BY A TRACTOR TRAILER UNIT WHILE PARKED AT AN ACCIDENT SCENE ON I 95.

IN CLOSING, EXPERIENCE TELLS US THAT MORE LIGHTS AND MORE COLORS ARE NOT ALWAYS THE SOLUTION TO THE OVERALL PROBLEM OF SCENE SAFETY. IT IS OUR BELIEF THAT THE CONFUSION AND POTENTIAL PROBLEMS CREATED BY ADDING TRADITIONAL POLICE LIGHTS TO FIRE VEHICLES GREATLY OUTWEIGH ANY PERCEIVED BENEFIT. WE UNDERSTAND AND SHARE THE DESIRE OF THE FIRE AND EMS SERVICES TO SAFEGUARD THEIR PERSONNEL, HOWEVER WE FEEL THAT THIS BILL WILL NOT ACCOMPLISH THAT GOAL.

AGAIN, I URGE YOU ON BEHALF OF THE STATE POLICE TO VOTE AGAINST THIS BILL. I WOULD BE HAPPY TO ANSWER ANY QUESTIONS THAT YOU MIGHT HAVE.

OFFICE OF POLICY AND LEGAL ANALYSIS

Date: March 7, 2003

To: Transportation Committee

From: Nicole Dube, Legislative Analyst

LD 464 **A/A to Allow Fire and Emergency Medical Services Response Vehicles to Display One Blue Light at the Rear of the Vehicle**

SUMMARY

This bill allows a blue light to be mounted at the rear of authorized emergency vehicles.

TESTIMONY

Proponents:	Opponents:
• Increase safety on highways for firefighters and EMS personnel responding to emergency situations. • Blue light spectrum is seen from a greater distance. • Research indicates a combination of red, blue, and amber emergency lights provide optimum results in vehicle detection, moving traffic to adjacent lanes, and reducing traffic speed passing it. • A standardized system of emergency vehicle lighting is needed.	• May create confusion for the public who already have a clear understanding of the meaning of the color of lights displayed by emergency vehicles. • Addition of blue lights would provide little safety benefit to responding personnel. • In the past two years, Maine State Police cruisers have been struck 8 times while parked with emergency lights displayed at an accident/crime scene. • Other factors other than color such as the height of the lights, driving behavior, and scene behavior affect effectiveness of the lights.

POTENTIAL ISSUES OR TECHNICAL PROBLEMS:

- The Committee asked for information regarding National Fire Protection Association standards regarding the use of blue lights. Current standards do not address the issue of blue lights.
- The Committee asked Lt. Christopher Grotton of the Maine State Police to provide studies against the use of blue lights by fire and EMS vehicles.

FISCAL IMPACT:

Not yet determined

Approved: 2/27/03 mac

121st Maine Legislature
Office of Fiscal and Program Review

LD 464

An Act To Allow Fire and Emergency Medical Services Response Vehicles To Display One Blue Light at the Rear of the Vehicle

LR0672(01)
Fiscal Note for Original Bill
Sponsor: Rep. Bull of Freeport
Committee: Transportation
Fiscal Note Required: No

Fiscal Note

No fiscal impact.

Approved: 06/30/03 mac

121st Maine Legislature
Office of Fiscal and Program Review

LD 464

An Act To Allow Fire and Emergency Medical Services Response Vehicles To Display One Blue Light at the Rear of the Vehicle

LR0672(02)
Fiscal Note for Bill as Engrossed with:
No Amendments
Committee: Transportation

Fiscal Note

No fiscal impact.

COMMITTEE VOTING TALLY SHEET

LD # or Confirmation: 464

Committee: TRANSPORTATION

Date: 3/7/03

Motion: OTP / ONTP

Motion by: Rep. McNeil

Seconded by: Rep. Damon

	Those Voting in Favor of the Motion	Recommendation of those opposed to the Motion					Absent	Abstain
		ONTP	OPT	OTP-AM	New Draft	Re-Refer		
1 Rep. Sampson	X							
2 Rep. Jodrey		X						
3 Rep. Marley	X							
4. Rep. McNeil	X							
5. Rep. Collins		X						
6. Rep. Usher (chair)	X							
7. Sen . Hatch (chair)	X							
8. Sen. Savage		X						
9. Sen. Damon	X							
10. Rep. Browne	X							
11. Rep Marrache`	X							
12. Rep. McKenney		X						
13. Rep. Paradis	X							
TOTALS	9	5						

9 5

MAJORITY

HOUSE REPORT

THE COMMITTEE ON Transportation

to which was referred the following:

An Act To Allow Fire and Emergency Medical Services Response Vehicles To Display One Blue Light at the Rear of the Vehicle

H.P. 356 L.D. 464

has had the same under consideration, and asks leave to report that the same
OUGHT TO PASS

(Signature)	of For the Committee
Sen. Hatch of Somerset	Pamela H. Hatch
Rep. Usher of Westbrook	Ronald E. Usher
Sen. Damon of Hancock	Dennis S. Damon
Rep. Sampson of Auburn	Sonya Sampson
Rep. Marley of Portland	
Rep. Browne of Vassalboro	William P Browne
Rep. Marrache of Waterville	Lisa T. Marrache
Rep. Paradis of Frenchville	Rosaire Paradis
Rep. McNeil of Rockland	Deborah McNeil
(Type) Rep. of (Town) and/or Sen. of (County)	(Signatures)

HOUSE REPORT

MINORITY

HOUSE REPORT

THE COMMITTEE ON Transportation

to which was referred the following:

An Act To Allow Fire and Emergency Medical Services Response Vehicles To Display One Blue Light at the Rear of the Vehicle

H.P. 356 L.D. 464

has had the same under consideration, and asks leave to report that the same
OUGHT NOT TO PASS

_______________ of _______________

(Signature) For the Committee

Sen. Savage of Knox	Christine Savage
Rep. Jodrey of Bethel	Arthur R. Jodrey
Rep. Collins of Wells	Harold F. Collins
Rep. McKenney of Cumberland	R. McKenney

(Type) (Signatures)
Rep. of (Town) and/or Sen. of (County)

HOUSE REPORT