EMERGENCY WARNING LIGHT TECHNOLOGY

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I am sure that the first highway maintenance vehicle had no warning lights like we now know. Probably the earliest attempt at a warning system was to use the vehicles' own headlights and taillights during daytime operation. When the first true attempt at a dedicated warning light for highway maintenance vehicles was made is also a mystery to me. The need for warning lights probably followed on the heels of the example set by public safety agencies such as fire, ambulance and law enforcement. These agencies differ from road maintenance vehicles by the fact that public safety vehicles are generally traveling faster than prevailing traffic, while road maintenance vehicles are generally moving slower than traffic or are stationary. As the numbers of motor vehicles on the road increased, so did the probability of collisions with highway maintenance vehicles. We now have a need for emergency warning lights on road maintenance vehicles. These vehicles fill the full spectrum from small vehicles such as supervisor's cars and tractor style mowers to mammoth snowplow trucks and portable bridge inspection equipment. Each vehicle has a different method of operation and a different profile. What works well on one vehicle may prove to be inadequate on another vehicle.

The purpose of warning lights is multifold. First and foremost they are to warn the general motoring public that a highway maintenance vehicle is sharing the road with them. With enough warning time an operator can make the appropriate adjustments to his driving, like braking or changing lanes. Since the general motoring public is warned, this creates a safer work environment for the maintenance personnel. By the use of warning lights we have a win-win situation.

Warning lights also may define the size, shape and purpose of a vehicle. The best example of this is to activate the four way flashers on your own personal vehicle. The rear facing signal lights flash simultaneously and the front facing signal lights also flash simultaneously. This defines the width of the vehicle when viewed from either the front or rear. Most states require any vehicle on a limited access highway that travel below a minimum posted speed to use their four way flashers. This type of warning system is required by law on all passenger vehicles. Multiple emergency warning lights mounted at the extreme edges of the vehicle will be more effective at defining the width of the vehicle than a single warning light. Again, the four-way flasher example reinforces this fact.

The color of emergency warning lights can provide a message about the agency using the lights. In most states public safety agencies use red, blue and clear lights for their vehicles. At this time there is no uniform standard regarding emergency lights that is embraced by all states. Amber seems to be the accepted color for road maintenance vehicles in all states. There is a limited use of blue in addition to the amber in some states located in the snow belt. Minnesota Department of Transportation uses blue in addition to the amber year round, while Alaska Department of Transportation defines the seasonal use of blue auxiliary lights. Colorado Department of Transportation uses blue light in addition to amber only while involved in a snow clearing operation. In this example the general motoring public is warned that a snow clearing operation is in progress and that certain types of equipment may be in use such as snowplows, wing plows and sand spreaders or deicing equipment. There is a move to separate the emergency warning lights from other lights used to provide a message. The use of arrow boards and other smaller auxiliary directional devices is on the increase. With greater speed and traffic density it is imperative that the general motoring public be alerted at greater and greater distances and that a course of action be suggested. These direction indicating devices range from full size arrow boards measuring 1.22 meters (4 feet) x 2.44 meters (8 feet) to miniature moving light displays measuring 10.16 centimeters (4 inches) x 1.12 meters (44 inches). Multiple functions are standard features on these direction indicating products and usually include a left indicating display, a right indicating display, a split display moving from the center toward both ends, and a flash display used for auxiliary warning when providing a direction is not necessary. The light display may be switched on or off and the function changed from the driver's compartment while the vehicle is in motion. This is a great advantage over directional devices that must have the display changed by hand. Some of the direction arrow devices even have an LED display that emulates the operation of the lighted arrow display, giving the operator confirmation that the device is working and in the proper function. The newest innovation in this product line is the ability to modify the pattern in which the lights are displayed. For instance in the full size arrow board displaying a left arrow function, the lights can sequence from right to left one at a time, two at a time, three at a time, build to a solid left arrow, or flash the entire arrow on at one time.

Each state controls the use of emergency warning lights by legislation. They specify which agencies must use warning lights of a particular configuration and color. They also regulate the private use of warning lights by contractors and volunteer emergency personnel. In many states, the use of warning lights on private vehicles is by permit only. This type of control maintains certain standards and prevents the widespread proliferation of all kinds of warning lights on all kinds of vehicles. The over use of warning lights would dilute the urgency and meaning of the signal.

Certainly the legislative control of warning lights is an acknowledgment of liabilities involved in the use of emergency response or highway maintenance vehicles. It is also an acknowledgment of their responsibility to establish and maintain minimum requirements that emergency warning lights must meet. States also legislate the manner in which other vehicles are required to respond to emergency warning signals. This may be as sublime as courteously granting the right of way to a volunteer fire person or as stringent as pulling over and stopping for a fire truck or ambulance. In this fashion liabilities are identified and responded to in a prescribed, predictable manner. When dealing with an increasingly diverse motoring public, this is probably the best we can hope for.

Technology changes with time. During my twenty three-year tenure with Whelen Engineering Company I have seen many advances in emergency warning light technology. Without advances in technology we would be driving on tube style tires and we would still have breaker point ignition systems. It is imperative that legislative agencies and user agencies keep up with advances in technology. Anyone involved with computers knows how quickly technology changes and what those changes cost. What is hard to measure is what not keeping up with technology costs, especially when safety is the yardstick.

In the emergency warning light industry, the Society of Automotive Engineers, Inc. (SAE) is the organization that I am most familiar with. They publish recommended practices, test procedures, requirements and guidelines for the design and manufacturing of all kinds of automotive products. They are strictly an advisory organization, not an enforcement agency. Their committees and subcommittees are made up of individuals representing companies involved in the manufacturing of the products they are writing requirements for. This provides an interesting paradox. For all practical purposes the members of the committee are business competitors. There is a vested interest in not sharing proprietary information, and there is also an undercurrent to keep the standards low enough for all members to be able to meet them without advancing the state of technology. Why would a member vote to raise standards if it meant they would have to spend time and money on new technology to meet a higher standard? This is what I call the lowest common denominator syndrome. The advance of technology should not be stifled because an individual or company is unwilling or unable to keep up with the pack. This attitude does not serve the common good.

Emergency warning lights fall under the same laws of physics that rule all light. That intensity is inversely proportional to the square of the viewing distance. This is not a linear function, it is a logarithmic function. For example, as the viewing distance doubles, the intensity is reduced to one quarter of the original intensity. There are a number of environmental conditions, over which we have no control, that affect intensity such as snow, fog, rain, dust and smoke. These conditions can greatly reduce the distance that an emergency warning light is perceived.

When reviewing manufacturers printed literature it is important that the units of light measure are consistent. SAE uses candela-seconds as a standard unit of measure for all warning lights. Often times manufacturers will use candlepower, beam candlepower, joules, visible effective candlepower, peak candlepower, watts and watt-seconds as advertised units of measure. They are not all the same. Watts and joules are measures of power. Candlepower measures all light from ultraviolet to infrared. The light we are interested is the light we can see. This is the only light we can visually perceive as a warning signal. To convert visible effective candlepower to peak candlepower, multiply by 1,350. In this fashion a rather mundane number is magically converted to a much more impressive number with lots of zeros. This is good for the manufacturer advertising their product, and looks good on paper to the buyer. After all wouldn't you rather buy an emergency warning light with 2,000,000-peak candlepower instead of one with 1,500 visible effective candlepower? This is a good example of buyer beware.

The color of the dome or lens covering the light source also will have the effect of reducing light intensity. Lens thickness and color density are variables that affect attenuation. Thicker lenses and concentrated color density have a greater filtering capacity than thin lenses or weak color density. Placing a clear lens over the light source may reduce the intensity by 10%. Amber and blue lenses attenuate light intensity by approximately 30% while a red lens will reduce light output by up to 80%. It seems to be a paradox that the agencies with the greatest need for long-range warning are using lights with the worst color for light output.

At this time, the color of the warning light is the only way of communicating with the motoring public. Different agencies are assigned certain colors they may use. There are prescribed procedures that must be followed when encountering a vehicle displaying emergency warning lights. What are most important is that the signal is powerful enough to be seen at a distance that will allow reaction time, and that the signal be accurate, so that the response is immediate and appropriate.

Our human nature causes us to respond to anything out of the ordinary, a new smell, a strange sound, or a bright flash of light. Motoring conditions can vary from the serene environment of a quiet country lane to the busy hustle of an urban superhighway exchange. We are used to hearing the noise of traffic as well as headlights, daytime running lights, taillights, signal lights and brake lights. The device that we use to produce the warning signal must stand out from background of visual distractions. The warning signal must be visually apparent and command attention. It must be bright enough to overcome bright sunlight during daytime conditions and yet not be blinding during nighttime operation. By the same token it must be powerful enough to penetrate adverse climatic conditions such as snow, fog, dust and smoke. Here lies the paradox. How bright is bright enough and how bright is too bright? SAE has published test requirements that warning lights must meet to be approved. There is a minimum light requirement that must be met, but the upper limit is not defined. Is it not interesting that our government has set stringent fuel economy goals for the future but they do not address raising the minimum warning light standards?

There are a number of devices that qualify as emergency warning lights, each with its own unique characteristics and flaws. SAE has separated warning lights into several categories.

360 Degree Warning Devices project light in a 360-degree horizontal plane. It will produce a regularly repeating pattern of flashes to a stationary observer. This flash pattern can be accomplished by several methods. The simplest method is to interrupt the power to the light source. SAE considers this type of device a Flashing Signal Device. An electronic or relay circuit similar to a turn signal flasher regulated the flash rate and on time. The benefits of this type of device are its relative simplicity and no moving parts. The down side of the Flashing Signal Device is that the light output is directly related to the power of the light source. This means if you want a more powerful beacon, you need a more powerful light source. A higher wattage bulb requires more energy to operate it. This type of device also suffers from the lag time that it takes the bulb filament to turn on and reach full intensity. For example consider a beacon flashing 60 times per minute and having a 50% duty cycle, that is each flash is equal to the dark time between flashes. The bulb filament must turn on, reach full intensity, turn off and extinguish in one half second. The flashing duty cycle is hard on the bulb filament, the result being relatively short bulb life. Generally speaking, there are relatively few Flashing Signal Devices in mainstream use.

The second sub category of 360 Degree Warning Device is the Rotating Signal Device. This device produces a moving beam or beams of light by rotating either the light source or sources around a fixed axis, or by rotating one or more reflectors, lenses or mirrors around a fixed light source. This style of light has many advantages over the Flashing Signal Device. The light source or sources are steady burn, thus giving a constant full intensity output. Lamp life is greatly increased over the flashing style of beacon. Through the use of mirrors, reflectors or lenses the light source is concentrated into a beam of definite arc width, rather than a 360-degree dispersion. This increases the intensity without having to increase the power of the light source. The drawback to this type of warning device is that it requires a motor to create the motion. Motors are subject to mechanical wear, and often perform poorly in cold weather conditions. When the light sources are rotated, such as on the familiar two-sealed beam rotating beacons, brush contacts are required to operate the light sources. Both the motor and the brushes can contribute to radio frequency interference (RFI). This interference generally gets worse with the aging and wear of the Rotating Signal Device. Beacons that use a fixed light source and rotate either reflectors or lenses suffer from inconsistent intensity and light distribution patterns. This is caused by the constantly changing relationship between the lamp filament and the focal point of the lens or reflector. One unique property of the rotating signal device is to project multiple colors by using colored light sources or lenses. When viewed from a fixed location, a regularly repeating pattern would be witnessed. This is most often seen on ambulances and fire equipment using red and white lights in repeating patterns. In spite of the many drawbacks to this design of warning device, it is well established in the marketplace and is produced by many manufacturers.

Another type of Emergency Warning Light is the Oscillating Signal Device. In this instance one or more beams of light are caused to turn back and forth through a fixed arc. The sum total of all arcs must add up to at least 360 degrees. Colored light sources or lenses could be used to project different colors in each arc, similar to the rotating signal device mentioned above. Depending on the number of beams present, the arc width and the angular sweep, the stationary viewer may witness one color or a multiple colored pattern. Once again this is a mechanical assembly like the above Rotating Signal Device and will suffer all the same drawbacks of motors, connecting links, and brush contacts. This type of device, though never really popular, has for all practical purposes vanished from general use. It has been supplanted by the less complicated and more cost efficient Rotating Signal Device. The back and forth sweeping motion is certainly notable with this type of device and unique to its design, but there is no specific requirement that calls for the exclusive use of this device over any other approved warning device.

SAE recognizes flash rates from 1 Hz (60 flashes per minute) to 4 Hz (240 flashes per minute) in their document J 845. The main concern, however, is not flashrate, but effective intensity. The effective intensity is effected by three factors: flashrate, beam width, and the intensity of the light source. Let us examine each factor separately. If the other two factors remain constant and the flashrate is increased, then the effective intensity will be reduced. Conversely, if the flashrate is slowed down, then effective intensity will be increased. This argument can be taken to an illogical end, because as the flashrate becomes slower and slower, then the signal becomes more and more like a steady burning light. If beam width becomes the variable, then increasing the beam width will increase the apparent on time of the light, while decreasing the beam width will decrease the on time. Obviously increasing the intensity of the light source will increase the intensity of the beam and the generated signal. This is the more horsepower route most often taken. It is the easiest and most cost-effective way to get more light output in this type of design. With a higher wattage light source comes greater heat and more power consumption.

Designers have been experimenting with both the Rotating Signal Device and the Oscillating Signal Device since their inception with the intent of improving the warning signal produced. The laws of physics are always working against maximum efficiency in this type of device because energy is shared between the motor and the light source. Light sources have steadily improved from the incandescent filament bulb to the newer halogen cycle lamps, giving a brighter more truly white light with less heat output. The optics of lenses and reflectors can be modified to alter the beam width, or to produce rapid multiple flashes. The latest development in motor technology is the stepper motor. This motor can be addressed to either rotate through a complete circle, or to oscillate through a designated arc. To sum up mechanical warning lights, we are on a plateau and have been for some time. The marketplace is waiting for a technological breakthrough in this type of warning device.

The other major category of Emergency Warning Light is the Gaseous Discharge Warning Lamp, more commonly known as the Strobe. This type of device uses an electronic circuit to convert the direct current energy from the vehicle's electrical system, typically 12 volts DC, to a high voltage level generally between 400 and 600 volts. This high voltage energy is stored in one or more capacitors. A timing circuit triggers the release of this energy to be discharged into a lamp filled with Xenon gas. The strobe concept is parallel in principle to vehicular electronic ignition except that the strobe tube is substituted for the spark plug. Gaseous Discharge Warning Lamps range from low 2 watt output units generally used on fork lift equipment used indoors to 180 watt output units operating multiple strobe tubs, commonly used on ambulances and fire apparatus.

Credit for the invention of the Xenon strobe, in 1932, goes to Dr. Harold Edgerton. Strobes came to the vehicular warning light market in a round about way. They were commonly used in the photographic field, where they were triggered on demand. With the advent of an electronic circuit that allowed a regularly occurring flash rate, the Gaseous Discharge Warning Lamp was born. First used as a warning light on aircraft in the early 1960's, the strobe didn't appear in the vehicular marketplace until 1968. Strobe technology has made steady progress throughout the intervening years.

The first strobes were single flash devices. A single, short duration, high intensity flash was produced followed be a relatively long dark period, at the rate of 1 Hz. Being new, strobe-warning lights caused quite a stir when they were first used on the roadways. The motoring public was used to a less intense, longer duration flash. They claimed that this type of flash was irritating, disorienting and dangerous, especially at night. There was great controversy over the use of strobe warning devices during the late 1960's through the 1970's. Many manufacturers not involved in strobe technology engaged in smear campaigns to discredit strobes, claiming eye damage, brain wave interruption and the cause of epilepsy and sterility. This was an earlier example of the negative advertising style we are all so familiar with now. If those manufacturers spent as much time and money on research and development as they did on negative advertising then they too would be in the forefront of strobe technology. In retrospect, there were also enough independent studies to refute any negative claims about strobes. As a postscript to the above, most of the companies involved in the earlier smear campaigns are now selling strobe products.

The claim about strobes being irritating and disorienting at night was not without a basis in fact. During nighttime driving the eye is relatively dilated. A high intensity short duration flash happens so fast that it doesn't let the eye react by constricting during the flash sequence. Therefore the eye continues to receive high intensity flashes into a dilated pupil. Being used on emergency response vehicles traveling at elevated speeds at night caused poor tracking of the emergency vehicle. Under these conditions the emergency vehicle could appear to move well over 100 feet in the dark period between flashes. A 360-degree rotating or oscillating device always seems to give off a witness level of light between flashes thus allowing better tracking at night. Adding a low candlepower incandescent glow light to the strobe device was tried to improve nighttime tracking. This was a temporary solution. It did improve nighttime tracking but now there is a secondary device requiring electrical power.

One of the principle advantages of the Gaseous Discharge Warning Lamp is its great efficiency of turning electrical power to light. There is only the primary electronic system which converts the vehicle's electrical energy to the high voltage energy used to fire the xenon strobe tube. There is no secondary system such as in the mechanical rotating and oscillating 360-Degree Warning Devices. Being fully electronic, there are no moving parts which are affected by vibration, wear and temperature extremes. Radio Frequency Interference (RFI) can be minimized with a good design and should not change with the aging of the strobe light. Mechanical designs suffer from increasing radio frequency interference with the aging and wear of the device. Motors and brush contacts wear and build up carbon on the contacts, creating arcing and high resistance contacts. This gets to be a run away situation that will eventually lead to the failure of the mechanical device.

Comparing a mechanical 360-Degree Warning Device to a Gaseous Discharge Warning Lamp of equal intensity will demonstrate that the strobe device consumes less than half the current than the mechanical device. This becomes significant when operating other emergency warning equipment such as high power two-way radios, sirens, medical support equipment, and spotlights. This kind of equipment when operated individually or in combination can overload the capacity of the vehicle's electrical system. This can lead to discharged batteries or, over a longer period of time, early failure of electrical components such as alternators, voltage regulators and batteries. Even though the alternator is rated at 80 or 100 amps, that is at operating speed. At idle these alternators may only produce 40 amps. This output is easily overcome with moderate electrical equipment use. A Federal regulation for ambulances, KKK1822C, addresses the current consumption issue and allows only 35 amps for the entire emergency lighting system. Some large fire apparatus manufacturers have gone to an automatic electrical load management system, whereby the electrical cannot be overloaded. As you can see from these examples the Gaseous Discharge Warning Lamp certainly helps the current consumption cause.

The first double flash strobe device was pioneered in 1974. This device produced two strobes flashed in rapid sequence followed by a relatively longer dark period. The first primary flash was the more intense of the two. The smaller secondary flash functioned as a fill-in flash, tricking the viewer's eye into seeing a longer duration flash. This double flash sequence produced a flash that approximated the familiar two-sealed beam 360-Degree Rotating Signal Device. Improvements in electronic components allowed this breakthrough without a corresponding increase in current consumption. This addressed the complaint that strobes were too irritating and disorienting. As Gaseous Discharge Warning Devices gained mainstream acceptance, many large agencies began using strobes in their fleets. Strobes became the warning system of choice and many specifications were written around this type of light to the exclusion of other types of warning devices.

A low power circuit was developed in 1978. This addressed the complaint that strobes were too bright for nighttime use. This circuit, activated by the operator or through the use of a photocell, reduced light output by up to 85%. One must understand that when the strobes are operating in the low power condition, they do not meet the light output required for a SAE class 1 approval. The low power feature should only be used when the vehicle is stationary. The use of strobes in the low power mode while in motion is not advised and could put the agency in jeopardy of litigation if they are involved in any kind of accident. Imagine the scene of a major nighttime multiple motor vehicle accident. Police cars everywhere, tow trucks, fire apparatus and ambulances all with their warning lights operating. There also will probably be people working around the accident scene treating the injured, moving wrecked vehicles and others directing traffic. We have all passed this type of scene at some time. Chaos abounds. With all the bright flashing lights you may have difficulty concentrating or seeing people directing traffic. Now the lights, whose purpose is to warn, now become a liability to the safe execution of an accident scene. This is where Gaseous Discharge Warning Devices operating in low power becomes an asset. I, personally, am opposed to the use of an automatic photocell circuit for the activation of the low power mode. First of all the strobe will not meet output levels for a certified Emergency Warning Light. For instance a snow plow truck whose hours of operation extend beyond the daylight hours and into twilight or nighttime. The photocell circuit would react to the reduced ambient light available and at sometime shift the strobe warning system into low power mode. The vehicle operator may not be aware that this has taken place, and the vehicle is technically operating in an illegal condition. The second objection I have against photocell control is that the device is dumb. It is not able to ascertain what caused the reduced ambient light condition. It may have been caused by heavy fog, snow, smoke, or contamination built up on the photocell device itself. The use of a strobe in the low power-operating mode under these conditions is not only illegal, but potentially deadly. The control of the Emergency Warning Light System is better off left to the control of the vehicle operator. After all, the automatic high beam/low beam option on some luxury cars in the 1970's never became a mainstream product.

By the late 1980s and the early 1990s there were many manufacturers of strobe devices, ranging from low yield inexpensive devices for use by a stranded motorist to the high output professional devices for use by emergency agencies. The focus of research and development was to develop something that would make your device stand out from the crowd. Unique flash patterns with three, four, or five quick flashes per burst were tried by many manufacturers as well as constant high speed single flash sequences. All met with a certain measure of success. CometFlash7 was introduced with a four flash per burst flash pattern. This pattern is an expansion of the double flash concept whereby the first primary flash is significantly brighter than the three follow up secondary flashes. This flash pattern gives a 60% effective on-time. The benefits of this are better tracking at speed and better color saturation especially red.

The latest craze in Gaseous Discharge Warning Lamp technology is the ability to produce a multiple of flash patterns rather than only one pattern, be it single, double, or multiple. Microprocessor technology allows the operator to select the flash pattern by a switch control or the strobe device itself has a preprogrammed automatic sequence of flash patterns that repeat on a regular basis. At first examination this may seem like a cute gimmick, but it does have a very important application. Earlier we discussed that we react to changes from the ordinary. We are all familiar with warning lights and sirens, and in areas of high traffic concentrations they are the norm rather than the exception. They become ordinary and fail to capture the attention of the motoring public. Emergency vehicle operators have had to resort to switching their lights and sirens manually from one operating mode to another. Trying to pilot an emergency vehicle through traffic with one hand while operating the lights and siren with the other hand can be disastrous. Some of the latest generation of warning lights and sirens can be connected to the vehicle's steering wheel horn button. The entire warning system, both lights and siren, can be turned on, shifted from one operating mode to another, put into a secondary stand-by mode, or turned off by commands from the horn button. The vehicle operator never has to take his hands off the steering wheel or his eyes off the road. The ease of operation is simplified, and the risk of responding at speed is reduced.

One of the things we have gotten used to in our own personal vehicles is confirmation lights or gauges that indicate whether or not the equipment we have turned on is in actually working, or working properly. Over the years there were warning buzzers for door ajar, headlights left on, high beam indicators, low oil pressure, etc. Several years ago this concern was addressed with the introduction of diagnostic strobe equipment. Rather than relying on a lighted toggle switch or a pilot light which merely indicates that there is power to the switch, there is now strobe equipment that will give real time feed back from the Xenon strobe tube itself. A small LED panel in the operator's compartment gives a lighted LED for a strobe light turned on in the high power mode. If that strobe light is switched into the low power mode, the LED blinks once every four seconds. This keeps the operator informed that the strobe is operating in low power mode. If the Xenon strobe tube should fail to flash for any reason whatsoever, for instance a cracked lamp, a damaged cable, or if it merely becomes unplugged, the LED panel will blink once per second indicating a waning light not working. Knowing the condition of your warning system allows the operator to make an informed decision on how to respond to an emergency scene. In snow plowing operations that may last many hours, a warning light can fail at any time. It is especially important to know if your warning system is working properly and is visible to the motoring public. Taking this concept further is a warning system directed chiefly toward the law enforcement market. This system is fully diagnostic in real time as well as having a quick check feature. With the push of one button all warning lights, all accessory lights, and the siren are tested. Once again, any fault in the system is indicated on a control panel by a blinking LED. There is no need to operate each circuit separately and visually verify proper operation. The siren is tested at a frequency in the inaudible range, so it will not become a nuisance. Testing the warning system before each shift is a good idea and is part of the standard operating procedure, it often gets overlooked especially when it is raining or snowing outside. Without real time verification of the status of the warning system, the operator may be under the false impression that he is responding with all lights and siren working. This assumption can be dangerous.

This sums up where we began and where we are today. Where do we go from here? Certainly improvements in electronic components will increase the efficiency of all warning lights whether fully electronic or electronically controlled mechanical devices. New light sources that produce more light output per watt of input. Right now there are several manufacturers involved in developing warning devices using high intensity discharge (HID) lamps. This light source has been used for years in the medical field. It produces five times the light output at half the current consumption of a halogen lamp. It will last roughly five times as long as that same halogen bulb. The disadvantage to HID is the cost and the fact that it needs an electronic support package to operate it. This again adds cost to the product. At this time it is used only in mechanical devices. As fiber optic technology advances, there may be a special place, or niche market in the warning light field for it. Self-diagnostic and verification features may filter down into lower cost devices.

One of the obstacles to progress in the warning product industry is allowing the minimum requirements to remain the same from year to year. There is little real incentive for manufacturers to spend money on research and development of new technologies when the products designed in the 1970s will meet minimum requirements. Most agencies will buy the least expensive product that fulfills the requirement they are obligated to meet. Our society has reaped the benefits from increasingly stringent standards. Pollution laws have become stricter, Cooperate Average Fuel Economy has been increased, building codes have been tightened up, motor vehicle crash standards have been reviewed and made safer, and the list goes on. Certification agencies should stay abreast of new technology and embrace improvements in warning devices. Specification writing agencies should look to the best warning system, rather than the cheapest light. Old technology should be left behind. Let us not lose focus on our goal, making our roadways safer.