Low location lighting and the IMO requirements

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The need for good escape route lighting is well recognised. However, a number of incidents, resulting in deaths, brought into question the effectiveness of existing emergency lighting techniques. Generally, the maritime community is extremely safety conscious and has often reacted rapidly to incidents, with the introduction of new resolutions to improve safety. Unfortunately, there was still clear evidence to suggest that further improvements were required in providing the best conditions for safe egress in emergencies such as fire. A number of emergency lighting specialists had recognised the limitations of mounting luminaires (lighting fittings) on the ceiling to provide escape route lighting, especially in the presence of smoke. Various research projects were undertaken and the data indicated that lighting mounted on or close to the floor, below any smoke layer, offered significant improvements in escape potential. When this information was made available to the International Maritime Organisation (IMO), a task force was set up and a new Resolution (A752/18) was prepared for Low Location Lighting (LLL) to be installed in all ships carrying more than 36 passengers.

INTRODUCTION

No one can predict how well a product, process or system will perform in an emergency condition until a real incident occurs. When the product in question is intended to operate specifically in emergency conditions, such as escape route lighting, then satisfactory performance is vital. As the name implies, emergency lighting is designed to operate under abnormal conditions. The primary function of emergency lighting is to provide suitable visual conditions to assist rapid and safe escape in the event of an abnormal condition occurring, which may range from a simple loss of normal power through to a serious fire.

The UK emergency lighting industry has a history of over 20 years and in that time has expended millions of pounds on research and development. The modern emergency lighting luminaire is very reliable and generally accepted as offering optimum performance, yet disasters both onshore and at sea have continued to claim lives. Even following major changes in the application of emergency lighting, such as the introduction of supplementary lighting for ro-ro passenger ships (DTp Merchant Shipping Notice M1299), further problems in achieving successful evacuation under difficult conditions have indicated that the conventional overhead solution was not totally effective.

Investigation into disaster reports, such as that for the Scandinavian Star, indicate that people often died within a few metres of an exit simply because smoke had robbed them of their sight. Harrowing photographs of dozens of hand prints along a smoke sooted wall adjacent to a safe exit bear testimony to how close some people had got to escaping, but failed simply because they could not see where the escape door was. Clearly in these conditions the emergency lighting systems were not effective. What was required was a lighting system that could be as effective in clear conditions as the conventional ceiling mounted luminaries, but considerably more effective in the presence of smoke.

LIGHTING IN SMOKE CONDITIONS

Studies into the behaviour of smoke show that hot smoke quickly rises to the ceiling and then rolls along the space at high level, obscuring overhead lighting and information signs and forcing evacuees into a crouched or crawling position where the air is cooler and less toxic. This will be particularly true with the very low ceiling heights common in the corridors of modern passenger ships.

Obviously smoke extract systems will improve these conditions but the possibility of the overhead lighting being totally obscured or even damaged by the high temperature smoke cannot be ignored.

The conclusion that effectiveness could be improved by providing the required visual conditions from a lighting
Table I  Disability glare limits

<table>
<thead>
<tr>
<th>Mounting height above floor level ( h )</th>
<th>Escape route and anti-panic area lighting maximum luminous intensity</th>
<th>High risk task area lighting maximum luminous intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>( m )</td>
<td>( cd )</td>
<td>( cd )</td>
</tr>
<tr>
<td>( h &lt; 2.5 )</td>
<td>500</td>
<td>1000</td>
</tr>
<tr>
<td>( 2.5 \leq h &lt; 3 )</td>
<td>900</td>
<td>1800</td>
</tr>
<tr>
<td>( 3 \leq h &lt; 3.5 )</td>
<td>1600</td>
<td>3200</td>
</tr>
<tr>
<td>( 3.5 \leq h &lt; 4 )</td>
<td>2500</td>
<td>5000</td>
</tr>
<tr>
<td>( 4 \leq h &lt; 4.5 )</td>
<td>3500</td>
<td>7000</td>
</tr>
<tr>
<td>( h \geq 4.5 )</td>
<td>5000</td>
<td>10 000</td>
</tr>
</tbody>
</table>

NB: High contrast between a luminaire and its background may produce glare. In escape route lighting the main problem will be disability glare, in which the brightness of the luminaires may dazzle and prevent obstructions or signs being seen.

system mounted below any likely smoke layer was inevitable. However, producing a lighting system that would provide the necessary visual conditions and that would be suitable for mounting at such low levels was a new challenge. Generally, the principle of illuminating an area had been achieved by a small number of high mounted luminaires having quite high lumen outputs. It was well known that very bright sources mounted below 2m from the floor create unacceptable glare, and the lighting industry have set intensity limits for conventional emergency lighting installations to ensure that disability glare does not occur (Table I). In addition, conventional luminaires are too big to mount safely at floor level because they pose a physical hazard by protruding into the escape path.

Even after the necessary design and development work had been carried out to make low mounted lighting systems available, it was also clear that research into their effectiveness, and particularly their performance in smoke, would have to be carried out to ensure that they offered real benefits.

Despite these hurdles a number of organisations persevered with the challenge. The realisation that there was a need for improved escape route lighting systems had been steadily growing for a number of years and culminated
around 1991. At this time a number of independent research programmes were underway.

In the USA the National Institute of Standards and Technology carried out a very detailed evaluation of the visibility and recognisability of signs in smoke and the Federal Aviation Authority conducted an assessment of what type of light source would remain visible in smoke. Indeed, the Aviation Industry acted very swiftly and introduced floor mounted escape route marking systems into passenger aircraft. These were normally small tungsten lamp units or a linear electroluminescent system. As more systems became available more research was undertaken. New terms were applied to the application of floor mounted systems; in the USA they were referred to as Path Marking Systems and a more widespread description of the approach was Way Guidance or Way Finding. By 1992 there was sufficient research evidence to identify what was required to ensure that a low mounted system could be effective.

The available data, particularly that offered by H G Gross and the Building Research Establishment (BRE), created an understanding of the key elements required to keep people moving safely through an escape route in clear/dark conditions or in the presence of smoke. It was found that evacuees had to feel confident of where the safe route was in order to keep moving at reasonable speeds, and by delineating the route with luminous markers this confidence could be achieved. The more visible the luminous markers were then the more confident evacuees would feel. To achieve the clear visible delineation it was found that the luminous markers had to form an almost continuous line; and to remain visible, even in the presence of smoke, these markers had to provide a high surface luminance or offer sufficient intensity to penetrate the smoke. What was surprising to many was that the research suggested that illuminance on the floor was not critical. This conclusion was in direct opposition to the previous approach for providing ceiling mounted ‘illuminators’ to light the escape path.

### PRACTICAL LOW LOCATION LIGHTING (LLL) SYSTEMS

Researchers had established how a low mounted way guidance system should perform; it was then up to the manufacturers to provide the technology for suitable products. The new products would have to provide an almost continuous line of light, bright enough to remain visible in smoke but not so intense as to cause glare. The systems had to be small and discrete, safe and reliable, but, perhaps most importantly, these products had to be suitable for mounting at floor level, where they would take all types of physical abuse and may be subjected to environmental conditions ranging from regular floor cleaning to flooding, either accidentally or due to the operation of a sprinkler or fog extinguishing system.

The technologies adopted for use in the new low mounted systems were: photoluminescent; electroluminescent; incandescent lamps; light emitting diodes; and fluorescent lamps. The performance of these various technologies are compared in Table II.

As specific products became available some of the researchers carried on with their studies using actual installations and, again, Dr Webber at the BRE has prepared some of the finest reports in this field. The combination of emerging products, good research data and the interest in improving safety, expressed by several commercial sectors, created a number of product specifiers and regulators. The first commercial interest came from the USA building sector, where conventional emergency lighting was being supplemented with low mounted path marking systems. Underwriters Laboratories (UL) reacted quickly in producing a product safety and performance standard, UL 1994, and some states in the USA considered the introduction of legislation requiring the installation of low mounted path marking in public places.

### IMO AND LLL

While the USA were developing this interest there were also a number of pro-active initiatives coming from the UK. Much of this came as a result of the publication of BRE’s work and due to a strong lobby from a UK manufacturer who was producing a wide range of low mounted way guidance products. Late in 1992 the International Maritime Organisation (IMO) set up a Maritime Safety Committee Working Party, with Ms M Murtagh of the United States Coast Guard in the chair, to develop a resolution on LLL for Passenger Ships. The working party referred to the extensive research conducted on both sides of the Atlantic and quickly recognised the benefits offered by low mounted escape route lighting. By May 1993 the Working Party had reached a consensus and the Maritime Safety Committee released the Assembly Resolution A752(18) for incorporation into the SOLAS Convention. The resolution, titled ‘Guidelines for the evaluation, testing and application of low location lighting on passenger ships’, set out the criteria for systems to be

<table>
<thead>
<tr>
<th>System</th>
<th>Luminance (surface brightness)</th>
<th>Intensity (projected light)</th>
<th>Illuminance (light on floor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photoluminescent</td>
<td>140 mcd/m² decaying to 2 mcd/m²</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Electroluminescent</td>
<td>10 cd/m²</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LED</td>
<td>1000 cd/m² per emitter</td>
<td>250 mcd</td>
<td>0.5 lux</td>
</tr>
<tr>
<td>Cold cathode fluorescent</td>
<td>500 cd/m²</td>
<td>50 cd</td>
<td>1 lux</td>
</tr>
<tr>
<td>Incandescent</td>
<td>2000 cd/m² per lamp</td>
<td>50 cd</td>
<td>1 lux</td>
</tr>
</tbody>
</table>

*At centre position of point source.*
installed in all ships carrying more than 36 passengers. The timescales for implementation require all new ships to have LLL by October 1994 and all other ships to have installations completed by October 1997.

As with all documents of this type there is a degree of compromise in the performance values specified, but the Resolution is an excellent platform for the preparation of good LLL installations. Some of the key requirements include the following:

1. The LLL system should function for at least 60 min after its activation.
2. The system should be continuous except as interrupted by corridors and cabin doors, in order to provide a visible delineation along the escape route.
3. The LLL should be installed at least on one side of the corridor, either on the bulkhead within 300 mm of the deck or on the deck within 150 mm of the bulkhead.
4. The LLL system should go up to exit door handle height on the side of the handle.
5. Electrically powered LLL systems shall be connected to the emergency switchboard so that they may be powered from either the normal main source or the back up source of electrical power. For existing ships the LLL may be connected to the normal main source of electrical power providing that the LLL has its own independent battery back up.
6. Electrically powered LLL systems shall be arranged so that failure of any single light source or lighting strip will not result in the marking being ineffective.
7. Electrically powered LLL systems shall comply with the relevant requirements of EN60 598.2.22 at ambient temperatures of 40°C, plus the products must comply with vibration and electromagnetic interference requirements of IEC945 and have an ingress protection of at least IP55.

Although the various requirements are fairly precise they remain open to interpretation and experience has shown that the classification societies are taking different views, resulting in substantially different approaches to installations. This unfortunately means that on some ships a very basic photoluminescent system may gain approval, whereas on others an electrically powered system connected to the emergency switchboard will be required to have additional independent battery back up and 100% redundancy to allow for battery failure.

**ESSENTIAL FACTORS FOR AN LLL SYSTEM**

Using the experience that has been gained with LLL installations on ships such as P&O's Oriana, RCCL’s Legend of the Seas and Princess Cruises’ Sun Princess, it is possible to identify precisely what is required to provide an effective and reliable system that should be acceptable to the owners, passengers and classification societies.

The essential factors may be summarised as:

1. performance;
2. cost (initial and whole life);
3. aesthetics;
4. fitness for purpose;
5. certification.

The factors listed above shall be considered in turn.

1. **Performance.** The IMO Resolution only specifies minimum performance criteria, but it is important to remember that the minimum performance is not always the desired performance. It must be recognised that the LLL system may be required to operate in a disaster scenario and therefore may be the difference between life or death. The research discussed earlier clearly identified the relationship between the ‘brightness’ of the system and its visibility, particularly in smoke. Inherent limitations in some of the technologies has resulted in the specified values for luminous performance, ranging from luminance values as low as 2 mcd/m² from the surface of photoluminescent materials to an intensity value of 150 mcd from an incandescent lamp which will have a peak luminance value in the order of 2000 cd/m² (10M times greater than the minimum value specified for photoluminescent materials).

Unfortunately, for many of the people involved in specifying these systems the values relating to photometric performance mean very little. LLL systems that utilise area sources, such as photoluminescent and electroluminescent, are assessed by the apparent brightness of the surface. Therefore the larger the area the better the useful performance. Luminance (surface brightness) is measured in candelas per square metre. Although viewing geometry makes it impossible simply to calculate the intensity (candelas) emitted from a given area (square metres), it is reasonable to make rough comparisons with the intensity values specified for point sources, which are 35 mcd for Light Emitting Diodes (LEDs) or 150 mcd for lamps. It can be seen, therefore, that even the best area source which is electroluminescent at 10 cd/m² would require an area in the order of 0.35 m² to achieve the intensity of the lowest point source requirement, ie: 35 mcd for an LED, and photoluminescent material at 140 mcd/m² would require an area of 1.4 m² to offer equivalent performance. For reference purposes, a sheet of white paper on a desk within a standard office environment would have a luminance of approximately 150 cd/m².

The decision about the performance of an LLL system should therefore be more far reaching than simply accepting a quoted value in compliance with the specified minimum. Reputable product manufacturers should have access to simulated escape routes, where an LLL system can be demonstrated in clear and smoke logged conditions. There is no better way of ensuring that a system will offer genuine benefits to evacuees than witnessing the system in full operation.

2. **Cost.** Always a sensitive subject, but obviously of paramount importance to the operators, the overall cost of installing LLL must be justifiable. The total cost of a system comprises the initial product cost, the cost of
installation and the whole life cost, including servicing and maintenance. The requirements specified by the relevant classification society may also affect costs, resulting in differences from ship to ship. However, the main comparison is often based only on the initial cost of the various systems available. It is not unreasonable to suggest that the better the system is, the more it is likely to cost and it would be misleading to consider only initial product costs when evaluating competing systems.

Therefore factors such as performance, life expectancy and maintenance requirements must be considered to achieve a balanced view. Often what appears to be a cheap system will offer poor performance, short life or will require a very expensive installation process. Large passenger ships have areas where the volume of passenger movement creates substantial deterioration of materials at floor level. If the LLL system utilises inferior materials this kind of wear and tear will result in the need for total replacement very quickly. Also, some of the technologies will degrade faster in use than others, eg photoluminescent materials degrade due to the effects of ultra-violet radiation, abrasion and dirt, and will probably require replacement every four to five years. Electroluminescent lamps are very susceptible to degradation due to moisture and their performance decays with use, limiting their useful life to about 8000h of operation.

3. Aesthetics. It is said that beauty is in the eye of the beholder and therefore the aesthetics of an LLL system, although of crucial importance, become a subjective issue. It is difficult to suggest that 75 mm wide yellow / green photoluminescent strips can in any way be aesthetically pleasing, especially within a luxury cruise ship, but most other systems utilise some form of carrier and an outer housing, which can allow the product designer some scope for introducing stylish shapes and finishes.

4. Fitness for purpose. For safety equipment onboard ships fitness for purpose is without doubt the most important single consideration. If an LLL system is to provide its essential function whenever required, it must be designed to withstand the unique conditions associated with the current marine architecture. This obviously links back to the subject of cost, particularly maintenance and replacement costs.

5. Certification. Type approval from classification societies is a pre-requisite for any LLL system but this is only the start. When an LLL system is designed the relevant society must be consulted to ensure that the layout, performance and operation comply with their interpretation of the minimum requirements. These interpretations currently vary to a considerable extent. There have been designs where a light emitting diode (LED) system was installed in a ship powered by basic transformers directly from the 220V emergency switchboard, and with a radial supply connection to the LLL. This fully complies with the minimum requirements but does result in the possibility of a break in the LLL system or its radial supply cable, causing all of the markers beyond the break to fail to operate. At the other extreme there was a newbuild project, where a different classification society insisted that the same type of LED LLL system had to be powered from each end by two individual power supply units with integral batteries, each capable of operating the total load for 1h and both connected to the emergency switchboard. The operation modes offered by this design mean that the LLL system will come on when required from the normal source of electrical power, continue to operate from the emergency supply if the normal supply fails, then in the event of total loss of ship’s power the system will run from its own batteries, and in the event of a battery failure or a break in the system all of the LLL system will continue to operate from the secondary power supply unit. This degree of safety is obviously commendable but the cost to the operator is considerable.

An installation method that is considered to be a good compromise between the bare minimum and the ultimate safety approach is shown in Fig 1. This uses power supply units with integral batteries connected to the emergency switchboard and mounted in protected service ducts. Two PSUs are used for each fire zone per deck and they are connected to the LLL system in two separate ring circuits. This approach has so far gained approval from a number of classification societies.

Having identified these five key aspects it is possible to examine the available technologies and determine the advantages and disadvantages of each.

**AVAILABLE LAMP TECHNOLOGIES**

**Photoluminescent**

There are a few photoluminescent materials that are capable of complying with the minimum performance criteria given in the IMO Resolution. However, photoluminescence is totally dependent on the installed material receiving adequate illuminance prior to its activation. Modern ships often use very directional ceiling mounted lighting, providing good levels of illuminance on the deck but much lower levels on the bulkhead. This immediately brings into question the reliability of bulkhead mounted photoluminescent systems. In addition to this concern, it must be understood that the effective visibility of a photoluminescent system requires total darkness because the eye must adapt to the low levels of light before it can perceive the glow from the material. In total darkness the glow from a photoluminescent LLL system does provide good route delineation, but if there is any ambient light or if smoke enters the area the very low surface luminance values may result in the system becoming ineffective.

In terms of cost photoluminescent systems appear to be far cheaper than any rival system. The actual product is relatively cheap and the installation process is simple. However, there are the hidden costs of having to provide high ambient light levels at all material times and the need to replace the system as it degrades due to abrasion, dirt and UV deterioration.
It is extremely difficult to make a photoluminescent installation look attractive and fit in with the surrounding decor, and this will be a major factor for many passenger ship operators.

Photoluminescent LLL systems can be installed in a way that will ensure compliance with the minimum performance requirements of the IMO Resolution. However, concerns regarding the effectiveness of photoluminescent material, particularly in smoke logged conditions, leaves a large question about its fitness for purpose, and even its true ability to comply with the spirit of the Resolution, particularly if the scope is considered, because this makes it clear that the LLL system should be effective ‘when the normal emergency lighting is less effective due to smoke!’

Electroluminescent

Of all the electrically powered systems discussed in this paper the electroluminescent systems have the lowest luminous performance. There are a number of different phosphors, lamp technologies and power supplies available which allow a wide range of colours and luminance values to be achieved. From these it is possible to configure electroluminescent systems that offer significantly higher surface luminance values than the minimum limits given in the Resolution, but this often results in shorter operational life. One advantage of the electroluminescent LLL systems is that this technology can provide truly continuous markers which are very good at delineating the route, but the low surface luminance makes their performance in smoke far less effective.

The electroluminescent systems require high frequency inverter power supplies, substantial electrical insulation and physical protection of the electroluminescent lamps, resulting in a high initial purchase cost. However, the commercially available systems are generally fairly easy to install and do not require large or complex cable installations.
The major drawback relates to life, as the high light output versions in particular will require electroluminescent lamps to be replaced periodically.

A further advantage offered by electroluminescent systems is the very low profile of the lamps. This allows some very discrete and attractive installation designs, and it has been claimed that there have been ships successfully fitted with electroluminescent LLL systems, indicating acceptable fitness for purpose.

**Incandescent lamps**

Even if an LLL system barely complied with the IMO minimum requirements for incandescent lamps it would still be an effective system. The requirements are very stringent for incandescent systems. The 100 mm lamp spacings will provide a line of light that would appear almost continuous to the eye, and the luminous performance would ensure good visibility in all conditions and substantial levels of illumination on the deck.

The biggest problem with incandescent lamp systems is finding a tungsten filament lamp that can withstand the shock and vibration associated with operation onboard ships. Manufacturers turned to the aircraft industry to source a suitable lamp for incandescent systems and installations aboard fast-cat ferries have proved the systems’ fitness for purpose. Incandescent systems generally operate at higher currents than other electrical systems and therefore require larger power supplies. This can result in the system having a fairly high initial cost but a life expectancy of around 40 000h substantially offsets this.

Use of sub-miniature incandescent lamps has kept the size of the components forming the LLL system very small and attractive installation designs have been possible.

**Light emitting diodes**

LED systems now form the majority of commercially available LLL products, with at least two of the LLL manufacturers replacing their original electroluminescent lamps with new LED designs. The IMO requirement of 35 mcd peak intensity is actually very low but as long as the LEDs are positioned so that the peak intensity is in direct line of sight for an evacuee, even the low output system can be effective in all conditions.

The complexities of mounting LEDs in an appropriate way to ensure that they provide the correct viewing conditions and, as with all other electrically powered systems, the need to seal adequately the components for the IP55 requirements results in fairly high initial costs. However, the low energy consumption of LEDs means that small power supplies can be used and the very long life expectancy of around 100 000h offers excellent whole life costs. There have been more successful marine installations of LED LLL systems than of any other technology. Therefore, fitness for purpose of the technology itself has been well proven, although there are some concerns regarding LLL systems which utilise inferior materials in their design due to a desire to improve the aesthetics or to reduce the costs. The penalty of using lower grade materials in the construction is high maintenance costs, particularly on deck mounted systems where the system suffers the worst physical degradation.

**Fluorescent lamps**

The IMO Resolution does not set specific performance criteria for this type of system and therefore a fluorescent system will only need to provide the very low luminance value of 10 cd/m², which is also applied to electroluminescent systems. The biggest problem with fluorescent lamp systems is that it is unrealistic to produce a continuous system because of cost and due to the large physical size of the components. Therefore the systems could not comply with the Resolution and the design limitations will make it difficult to plan an attractive installation.

**FUTURE DEVELOPMENTS**

Due to the 1997 deadline, LLL systems are having to be installed within very tight timescales. It is therefore unlikely that any new technologies will become available in the short term. Some of the demands on the existing technologies include improved central monitoring and further investigations into providing more direction information from the LLL system. Central monitoring and addressable power supplies are becoming more readily available without reducing the reliability or effectiveness of the basic systems. However, some attempts to provide directional data or interlinking with smoke detectors have proved to reduce reliability, increase costs and introduce the potential for giving false information with catastrophic results. Currently, the approach of providing LLL is intended to delineate clearly the escape route and to provide suitable information for an evacuee to make the necessary decisions to move to a safe exit. Before any system actually attempts to take the decision process away from the evacuee it must be proven to the IMO and the classification societies that the system is foolproof.

The IMO will continue to review the technologies and will use experience from LLL installations to update and modify the Resolution as necessary. Possibly, sometime in the future, it will be recognised that the high performance electrically powered LLL systems can actually take the place of conventional emergency lighting in the escape routes. Such innovation will certainly please the operators and the decision may be a simple process once the maritime community has gained the relevant experience in the effectiveness of good LLL systems.

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NOMENCLATURE

Emergency Lighting: Lighting provided for use when the supply to the normal lighting fails.

Escape Route Lighting: Lighting provided to ensure that the means of escape can be effectively identified and safely used.

LED (Light Emitting Diode): Semiconductor junction having the addition of selective impurity atoms producing an excess of free electrons, resulting in junction electroluminescence under specified electrical conditions. The light output is generally monochromatic with the wavelength dependent on the junction materials.

Electroluminescence: Direct conversion of electrical energy into light.

Intensity: Luminous flux leaving a source in a particular direction within an element of solid angle.

Photoluminescence: Radiation is absorbed at one wavelength (usually ultraviolet) and re-emitted at a different wavelength (normally visible).

Luminance: Flow of light in a given direction from a point on the surface of the source divided by the projected area.

Glare: Excessive contrast between the light source and the background or over-bright light sources which inhibits the normal retinal image, therefore impairing visibility.
Discussion

B P Sharman (Lloyd’s Register of Shipping) I would like to thank Mr Wright for presenting a most informative paper on a subject which, in most cases, is technically unfamiliar to many engineers, with terms such as candela and lux, ie that of Illumination Engineering. Those of us who have experienced a demonstration of the operation of the various lighting systems under ‘cosmetic’ smoke conditions can readily appreciate the advantage of low location lighting, but can only begin to appreciate the horrific experience of a real fire situation where the smoke may be far darker and acrid.

As the paper states, there are many different types of systems available to be used and a number of manufacturers of these systems have made presentations to us, LR, with a view to their installation on classed vessels. Whilst their designs and equipment differ, the one thing that they would all appear to agree upon is that the IMO Resolution, A752(18), has a number of shortfalls and it therefore surprises me to read that the author considers the Resolution to be ‘an excellent platform for the preparation of good LLL installations’.

The matters which have come under criticism are:

1. The differing requirements dependent upon the source of illumination. Is it not technically possible to state an overall level of minimum luminance which could then be applied to any system?

2. The requirement for electroluminescent systems to function for 60 mins from the instant when the main power supply is removed. Does this mean that the material is required to have some residual luminance, and if so how much, or is it required that an alternative electrical power source be immediately available?

3. If, in the foregoing, an alternative electrical power source is to be available immediately, is it required that the other systems be so arranged? The resolution requires that electrically powered systems be powered by the main source of electrical power under normal circumstances and also by the emergency source of electrical power when it is in operation. No mention is made, for newbuildings, of powering the LLL system from the transitional source of emergency electrical power. What are the author’s views on these matters?

Such is the concern about the IMO Resolution that IACS has referred to the remarkably short time taken to publish the document and the assumption that classification societies would consider its requirements as absolute minimums.

1. The requirements given in the Resolution are based on actual products which were commercially available at the time the document was drafted. Although some reference was made to available research data, in my opinion the current performance values basically describe the operation of the lowest performance product in each technology. It should be possible to set more consistent performance criteria. There are two different considerations:

   a. luminance (the apparent brightness of a surface) for all area (planar) products which would include photoluminescent and electroluminescent;

   b. luminous intensity (the amount of light being projected from a source) for all small point sources such as light emitting diodes and incandescent lamps.

If the concept of providing a contiguous ‘line of light’ is accepted, then the area sources would be limited to a reasonable physical dimension and a minimum luminance value could be specified. However, the performances of photoluminescent material and electroluminescent products do not compare well. Electroluminescent products provide values 100 times greater than photoluminescent materials, ie: 10 cd/m² compared with 100 mcd/m². When considering point sources a contiguous installation still provides an effective line of light but the function of operation depends on fairly high levels of intensity being directed towards the evacuee. Incandescent lamps are generally omnidirectional and therefore emit useful levels of intensity in all directions. However, to achieve high luminous intensities the solid state Light Emitting Diodes have to incorporate a lens to focus the available light. This makes the devices highly directional, often having a beam angle (peak intensity down to half peak) of only 10–12 deg. It is therefore important to specify the direction of the intensity as well as the actual value. It is a fact that higher intensity values will remain more visible in adverse environmental conditions, with the only possible problem being the potential for glare when the intensities are too high.

In my opinion, the minimum specification for point source systems should be a peak intensity of not less than 100 mcd in the direction of the normal line of sight.

2. All electrical LLL systems are required to operate when the main power supply is removed. The IMO Resolution does not clearly specify the time allowed for this to occur. Emergency lighting specifications generally consider 2s to be the acceptable changeover period. Obviously, photoluminescent material will glow as soon as the ambient lighting is lost. However, the perform-

D B Wright (Existalite Ltd) Mr Sharman’s remarks regarding the shortfalls of the IMO Resolution A752(18) concur with many other key opinions. My own feelings regarding the Resolution being a good platform for the preparation of acceptable Low Location Lighting installations were based on the remarkably short time taken to publish the document and the assumption that classification societies would consider its requirements as absolute minimums.

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   a. luminance (the apparent brightness of a surface) for all area (planar) products which would include photoluminescent and electroluminescent;

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If the concept of providing a contiguous ‘line of light’ is accepted, then the area sources would be limited to a reasonable physical dimension and a minimum luminance value could be specified. However, the performances of photoluminescent material and electroluminescent products do not compare well. Electroluminescent products provide values 100 times greater than photoluminescent materials, ie: 10 cd/m² compared with 100 mcd/m². When considering point sources a contiguous installation still provides an effective line of light but the function of operation depends on fairly high levels of intensity being directed towards the evacuee. Incandescent lamps are generally omnidirectional and therefore emit useful levels of intensity in all directions. However, to achieve high luminous intensities the solid state Light Emitting Diodes have to incorporate a lens to focus the available light. This makes the devices highly directional, often having a beam angle (peak intensity down to half peak) of only 10–12 deg. It is therefore important to specify the direction of the intensity as well as the actual value. It is a fact that higher intensity values will remain more visible in adverse environmental conditions, with the only possible problem being the potential for glare when the intensities are too high.

In my opinion, the minimum specification for point source systems should be a peak intensity of not less than 100 mcd in the direction of the normal line of sight.

2. All electrical LLL systems are required to operate when the main power supply is removed. The IMO Resolution does not clearly specify the time allowed for this to occur. Emergency lighting specifications generally consider 2s to be the acceptable changeover period. Obviously, photoluminescent material will glow as soon as the ambient lighting is lost. However, the perform-

D B Wright (Existalite Ltd) Mr Sharman’s remarks regarding the shortfalls of the IMO Resolution A752(18) concur with many other key opinions. My own feelings regarding the Resolution being a good platform for the preparation of acceptable Low Location Lighting installations were based on the remarkably short time taken to publish the document and the assumption that classification societies would consider its requirements as absolute minimums.

1. The requirements given in the Resolution are based on actual products which were commercially available at the time the document was drafted. Although some reference was made to available research data, in my opinion the current performance values basically describe the operation of the lowest performance product in each technology. It should be possible to set more consistent performance criteria. There are two different considerations:

   a. luminance (the apparent brightness of a surface) for all area (planar) products which would include photoluminescent and electroluminescent;

   b. luminous intensity (the amount of light being projected from a source) for all small point sources such as light emitting diodes and incandescent lamps.

If the concept of providing a contiguous ‘line of light’ is accepted, then the area sources would be limited to a reasonable physical dimension and a minimum luminance value could be specified. However, the performances of photoluminescent material and electroluminescent products do not compare well. Electroluminescent products provide values 100 times greater than photoluminescent materials, ie: 10 cd/m² compared with 100 mcd/m². When considering point sources a contiguous installation still provides an effective line of light but the function of operation depends on fairly high levels of intensity being directed towards the evacuee. Incandescent lamps are generally omnidirectional and therefore emit useful levels of intensity in all directions. However, to achieve high luminous intensities the solid state Light Emitting Diodes have to incorporate a lens to focus the available light. This makes the devices highly directional, often having a beam angle (peak intensity down to half peak) of only 10–12 deg. It is therefore important to specify the direction of the intensity as well as the actual value. It is a fact that higher intensity values will remain more visible in adverse environmental conditions, with the only possible problem being the potential for glare when the intensities are too high.

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3. In my opinion all LLL systems should be provided with local power supplies with integral batteries, to avoid the potential of the whole system being rendered ineffective by a major incident affecting the primary electrical supply system (generators, distribution boards, cabling, etc).

However, the Resolution allows connection to the central emergency switchboard and with many newbuilds this raises a potential problem with the LLL power supply units. The majority of electrically powered LLL systems operate at extra low voltage or have an inverter in circuit, and in both cases power supply units must be installed throughout the vessel (typically two per fire zone per deck). These units normally have wire wound transformers on the inputs which are only suited to ac supplies. However, some newbuilds have dc transition supplies fed from central battery units. In these cases special LLL power supply units suitable for ac and dc operation must be used.

M W S Matthews (Self-employed)

1. All ships are to have LLL by December 1997. Does this include tankers and cargo vessels?

2. Identification of stairways would be helpful, in the case of a capsized vessel.

3. LLL systems are to be type tested when installed on vessels. To whom do the manufacturer and/or installer apply for type testing?

D B Wright (Existalite Ltd)

1. All ships carrying 36 or more passengers and operating on international routes must have LLL fitted in passenger areas by November 1997. All crew areas for these ships must have LLL installed by November 1998. Currently legislation does not affect tankers or cargo vessels, assuming that they do not carry ‘passengers’.

2. The principles of providing clear route identification and designating the top and bottom of a stairway using LLL have been proven to be very effective in clear and smoke laden conditions. Obviously, in the event of a capsise, the problems are very different. However, I would anticipate that the stair identification could still be very useful.

3. LLL products can be type approved prior to installation and in my experience no order will be gained if this is not done. Product type approval is a service provided by most marine classification societies. Organisations such as Lloyd’s Register, Det Norske Veritas and RINA all have very straightforward policies. Others, such as the American Bureau of Shipping, require specific national assessment such as Underwriters Laboratories listing. The installation of the LLL system must also be assessed by the relevant classification society and flag state approval bodies.

B Finlay (Royal Fleet Auxiliary, Bath) I would like to thank Mr Wright for presenting an excellent paper. I am a serving officer with the Royal Fleet Auxiliary, currently working in the RFA’s design and safety group. It has already been made clear to me by the MSA that electrically operated Low Location Lighting is the only system that satisfies their requirements in our passenger ships.

There are two points I would like to make:

1. Does the author have evidence of continued operation in very dense smoke?

2. Does the IMO Resolution give any indication about how LLL systems will be activated?

J Lauder (Marine Safety Agency) In order to clarify as to which passenger ship’s Low Location Lighting is required to be fitted, the IMO Requirements apply to those only engaged on international voyages.

My question is regarding the important aspect of signage and if any form of standardisation is being prepared, because many signs onboard ships can be very misleading to passengers and many different sizes have been fitted, some so small it is impossible to read them.

D B Wright (Existalite Ltd) The scope of the IMO Resolution A752(18) is restricted to Low Location Lighting with a very general reference to signage. In my opinion, all LLL systems should incorporate (or illuminate) basic signs giving information regarding the route to a safe exit. The important criteria for such signs is that they should be quickly visible and understandable. To achieve this using the LLL technologies I believe that the requirement should be for simple and relatively large signs. As an example, the word ‘EXIT’ is still internationally understood. For a low location exit sign to be visible, recognisable and legible in an emergency condition, possibly involving smoke, I believe the letters should be at least 30 mm high and must contrast well against the background.

Signage is a very complex subject and will require considerable debate, but I agree with Mr Lauder that standardisation is highly desirable.