Innovative emergency escape route lighting based on a light source of LED-clusters

Application for use during the whisky maturation process

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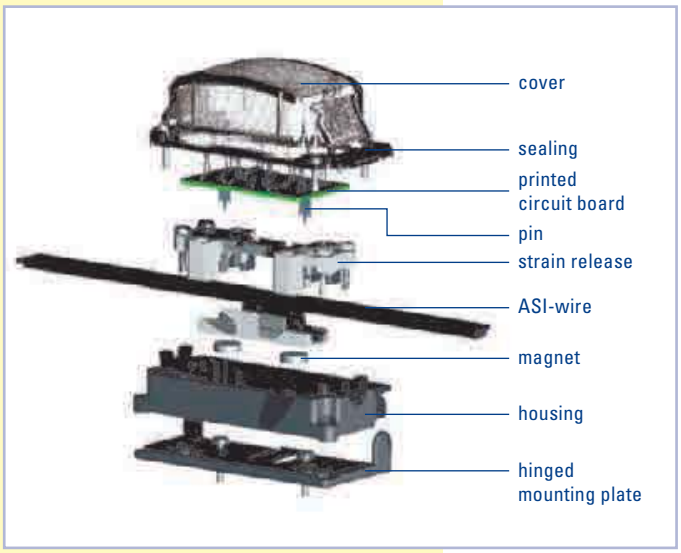

Figure 1: Sketch of the cluster setup

The use of Light Emitting Diodes (LED) in industrial applications has increased significantly over the last years. This is mainly due to their increased life span and their impressive increase in efficiency – up to 100 lm/W for white LEDs.

Examples of major markets for LED technology are the automotive and telecommunication sectors, where they are used for the backlighting of dashboards and displays, as well as, in car headlights and brake lights .

LED technology is used in the mentioned sectors based on their:

- immense service life time of up to 100,000 h
- increased efficiency
- small footprint and low power consumption
- large working temperature range
- immediate light availability

Based on these properties, LEDs have also been introduced as an alternative solution in hazardous areas. One of the first applications of LEDs in hazardous areas was in indicator lamps during the 1970s [1], [2]. The use of LEDs instead of traditional micro incandescent lamps resulted in a significant increase in service time, thus reducing maintenance costs. At the same time, a wide voltage supply range and a better indication capability was achieved. Another typical use for LED technology in hazardous areas is in hand torches.

Development of LED escape route lighting

During the maturation process of whisky a significant amount of high percentage alcohol (approximately 63,5 % alcohol by volume) evaporates (the so-called ›angel's share‹) into the atmosphere (approximately 2 % volume per annum). Thus, warehouses where whisky is stored are classified as Zone 2 hazardous areas.

To perform regular maintenance tasks, these warehouses need to be accessed by distillery workers. In order to allow a safe working environment an appropriate emergency lighting system is required. Today, it is mandatory that workers wear certain Personal Protective Equipment (PPE), such as head torches when they enter the warehouse. In case of an emergency these are then used to safely leave the premise. The head torches however, were not meant as a permanent solution for an emergency lighting system. Furthermore, these head torches are uncomfortable to wear and put a large strain on the wearer.

Therefore R. STAHL has developed explosion protected escape route lighting using LED's.

Requirements on escape route lighting

There are two major requirements for the emergency lighting in the warehouses. Firstly, the warehouses should be electrically isolated at times when nobody is working in them and secondly, the emergency light fittings can only leave a small footprint, due to the fact that stacker units (fork lifts) are operated in the warehouses, and could potentially destroy the light fittings. Thus, an innovative way of performing the emergency lighting was necessary. Firstly, definite values of illumination on the escape route are required, and secondly, the mechanical design of the light fittings has to be suitable for the rough use.

Illumination requirements

The main purpose of emergency escape lighting is to provide visibility for evacuation purposes. The requirements are set out in the European Standard EN 1838 [3] as follows:

- mounting of luminaries at least 2 m above the floor
- signs provided at all exits intended to be used in an emergency and along escape routes shall be illuminated to indicate unambiguously the route of escape
- escape lighting luminaire complying with IEC/EN 60598-2-22 [4]
- for escape routes up to 2 m in width, the horizontal illuminances on the floor along the centre line of an escape route shall not be less than 1 lx and the central band consisting of not less than half of the width of the route shall be illuminated to a minimum of 50 % of that value
- the minimum duration of the illumination of the emergency escape lighting allowed for escape purposes shall be 1 h
- the emergency escape route lighting shall reach 50 % of the required illuminance level within 5 s and full required illuminance within 60 s. ➔

Figure 2: Sketch of mounting arrangement

Design requirements

Due to the difficult environment, the spatial constraints, and the heavy stress on the emergency lighting in the warehouses, the following parameters were required:

- mechanically and chemicaly robust design
- small footprint (access with fork lifts to the casks is regularly necessary)
- the lighting needs to be able to be connected to a Central Battery System (CBS)
- large working temperature range
- low maintenance requirement
- flexible installation method
- adjustable illumination angles

Technical realisation of escape route lighting

Technically, the design is based on the type of protection ›n‹ for non-sparking apparatus ›Ex nA‹. A series of eight high power T-type LEDs with a large luminous efficacy form a LED cluster. The LEDs and their electronics are enclosed in a polycarbonate housing designed for optimized light distribution and additional protection. The completed LED cluster is then clipped on a standard ASI (Actuator Sensor Interface) bus cable for electrical connection. The basic principle of design is illustrated in Figure 1.

The decision to use T-type LEDs instead of the SMD (Surface Mount Device) type is based on the higher measured illuminance (approximately double the illuminance for the T-type LEDs) on the ground. The SMD LEDs show similar efficacy, but due to their broader light distribution the necessary light intensity on the floor could not be achieved.

Contact between the ASI cable and the electronics is achieved through a piercing technology, which guarantees continuous connection between the electronics and the ASI cable, thus no sparking takes place. The piercing technology will also be applicable with standard cable types. This is made possible via a spring arrangement in the housing, which keeps the pressure constant where the piercing elements go through the cores.

The implemented electronics are based on a simple rectifier where the LEDs are put in series with a standard resistance, running on a 24 V AC or DC supply. In order to connect the LED clusters on a Central Battery System (CBS), each circuit of LED clusters is put in series with a switching power supply that is able to handle an input voltage of 240 V AC as well as 216 V DC (battery voltage from the CBS), and generates the mentioned 24 V AC or DC.

By using the profiled ASI cable the mounting of the LED clusters can only be done in one orientation, and therefore the risk of faulty installation is significantly reduced. Furthermore, the electronics are designed in such a manner that the electronic board can be put on the piercing setup in any orientation.

The flexible mounting of the LED clusters is achieved via several alternative methods. On the back of the cluster plate are two magnets that allow the cluster to be easily attached on any magnetic surface. Additionally, the clusters can be fixed with screws via two entry holes (Figure 2).

Through a hinge on the backside of the cluster (Figure 2), the flexibility in adjusting the light distribution on the floor is considerably improved. This variability was necessary because of the different layouts of each individual warehouse. In doing this it can be guaranteed that the escape pathway is illuminated correctly. An additional advantage of tilting the LED cluster is that any glare effects can be minimized.

	Illuminance [lx]				
	Rack 47	Rack 41	Rack 32	Rack 25	Average of rack readings
Main passageway	1.10	0.94	3.87	2.57	2.12
Escape passageway	1.23	0.91	0.99	1.76	1.22

Table 1: Illuminance readings at various positions in the warehouse

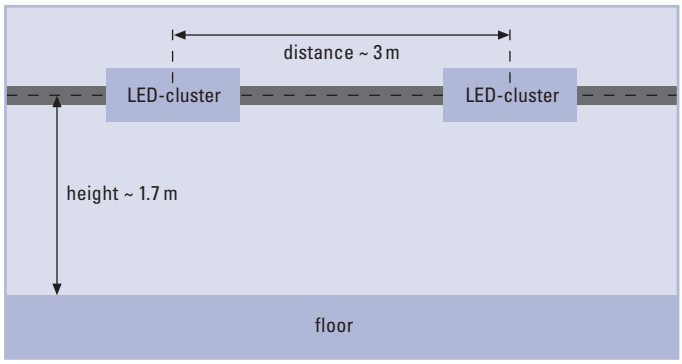

Figure 3: Setup of the LED clusters in distance and height

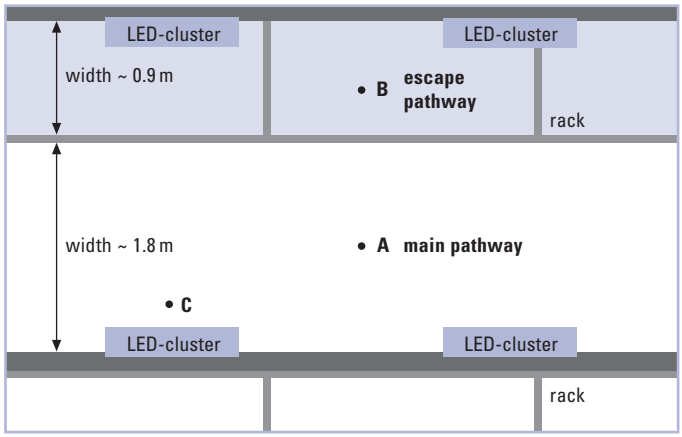

Figure 4: Measurement positions and width of passageways

The ingress protection for the entire LED cluster is achieved by using specially designed ASI gaskets. This way an ingress protection degree of IP 66/67 is possible.

The complete LED cluster measures approximately 76 mm in width, 40 mm in height and 40 mm in depth thus the required compact solution for the warehouses is achieved.

Experiences by end-user

The newly developed design of the LED clusters were successfully tested during a three month trial period in one of the mentioned maturation warehouses.

Two circuits were installed, each consisting of 25 LED clusters. The lights were fixed at approximately 1.7 m heights and about 3 m apart, with an emergency pathway width of approximately 0.9 m and a main passageway of approximately 1.8 m (Figure 3 and Figure 4). The LED clusters were mounted on the described ASI cable and then fixed along the racks around the warehouse.

The measurements performed during the last quarter of 2005 produced the results shown in Table 1.

The measurement points for the main passageway A and for the escape passageway B are illustrated in Figure 4. The results show that a sufficient lighting level can be achieved with the LED design for leaving the hazardous area in an emergency situation. The deviations between the various readings at the different racks are due to the fact that the orientation of the LED clusters have not been optimized at this stage. However, it could be shown that the average illuminance of the readings are well above the required levels.

Measurements done on the floor directly in front of the LED cluster (measurement point C, Figure 4) gave illuminance readings of approximately 16.82 lx and the lighting level achieved at the stair cases were 1.23 lx.

Due to the voltage drop along the cable, the current technical solution allows for approximately 75 LED clusters to be put on a 225 m length of cable, assuming the clusters are positioned 3 m apart.

Result of the trial periode

It could be shown that the LED cluster design is an efficient escape route lighting system, in accordance with the requirements set out by EN 1838.

The results illustrate that the LED clusters show no deterioration in light intensity during the trial period. Additionally, the LED clusters cope well with the harsh environment in the warehouses and importantly do not disturb the warehouse workers in their daily work. This is due to their compact and robust design. Another major advantage of the new development is that in an emergency situation the light intensity is available immediately, thus the solution exhibits an increased safety in the warehouses. Due to the flexible adjustment of the LED clusters via the hinge the light distribution can easily be changed to suit the necessary lighting task.

Due to the long lifetime of the LEDs, the maintenance cycles can be reduced and thus a potential cost reduction of up to 70 % over the life cycle of the installation is feasible. The use of the LED clusters not only results in a reduction in maintenance costs, it also reduces the initial investment by approximately 5 % (dependent on the type of application). From an end-user's perspective these are two major advantages for using this new technology. Plus, it is advantageous that the LED clusters can easily be retrofitted into an existing warehouse without touching the existing lighting scheme. In these particular warehouse cases standard emergency lighting could not be used due to space limitations.

For the future several further applications are possible, e.g. a version for a hazardous area Zone 1 as well as the change to a wide voltage range application.

With regards to the emergency escape route lighting, it is possible to implement intelligence into the LED cluster. In this case the LED cluster will be part of a facility management system and would allow the operator to use it as dynamic escape route lighting. In case of a hazardous situation in the plant or building, the system would then dynamically exhibit the fastest way out of the building dependent on the location of the hazard.

At present the newly developed escape route lighting should be combined with traditional emergency signs, particularly at escape doors. This is necessary due to the fact that the LED cluster design is too small to be recognised at a distance. However, a combination of the LED clusters with light up emergency signs would be possible.

References

[1] Helmut Würz, , Patentschrift DE 2531968 C2

[2] W.R. Slominski, Indicating Lamps with Explosionproof Luminescent (Light Emitting) Diodes ,Ex Magazine No.4 June 1978, p. 26

[3] EN 1838:1999, Lighting applications – Emergency lighting

[4] IEC/EN 60598-2-22:1997, modified + A1:2003, Luminaires – Part 2–22: Particular requirements – Luminaires for emergency lighting