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Analysis of liquid crystal displays application for the construction of variable message emergency lighting luminaires

Abstract. *Nowadays luminaire allow to change luminous flux dynamically by means of regulators and dimmers.Additionally modern LED luminaires can change their colorimetric parameters, mainly color temperature. Emergency lighting luminaires should provide adequate visibility of the presented content, both in terms of luminance and its distribution as well as in terms of color. In the paper the analysis of the application of displays built in LCD, OLED, DLP andLCoS technologyto construct emergency and evacuation lighting luminaireswith variable and programmable content.*

Streszczenie*. Oprawy oświetleniowe pozwalają obecnie na dynamiczną zmianę strumienia świetlnego poprzez regulatory i ściemniacze. Nowoczesne oprawy LED dają dodatkowo możliwość modyfikacji parametrów kolorymetrycznych, głównie temperatury barwowej. Oprawy oświetlenia awaryjnego powinny zapewniać odpowiednią widoczność prezentowanych treści, zarówno pod względem luminancji i jej rozkładu jak również pod względem barwy. W artykule przeprowadzona będzie analiza zastosowania wyświetlaczy zbudowanych w technologii LCD, OLED, DLP i LCoS do konstruowania opraw oświetlenia awaryjnego i ewakuacyjnego o zmiennej i programowanej treści. (****Analiza wykorzystania wyświetlaczy ciekłokrystalicznych do budowy opraw oświetlenia awaryjnego o zmiennej treści****).*

Słowa kluczowe: LCD, oświetlenie awaryjne, oprawa oświetleniowa
Keywords: LCD, emergency lighting, luminairs

Introduction

Emergency and escapelighting, approved for use in Poland, should be constructed in accordance with the requirements of relevant legislation and legal regulations. Based on the Decree of the Minister of Infrastructuredated March 12, 2009 (Dz.U. Nr 56 poz.461 z dn. 7 kwietnia 2009 r.) amending Regulation on technical conditions to be met by buildings and their location: “Emergency lighting should be carried out in accordance with Polish Standards regarding requirements in this field”[1]. Currently, the applicable standard in the field of emergency lighting is the PN-EN 1838:2013-11[2] standard, which in its content refers to other standards describing the emergency lighting: PN-EN 60598-2-9[11], PN-EN 50172:2005[9], PN-EN 62034:2012[12]. All electrical and photometric requirements specified in the standard PN-EN 1838:2013-11[2] relate to the minimum, below which it is unacceptable to decrease the selected parameter over the entire lifetime[2]. Hence the conclusion that the entire emergency lighting system should be designed and implemented with the system of maintenance.

Emergency lighting is realized mainly luminaires that emit luminous flux directly on the evacuation routes. The current standard PN-EN 1838:2013-11[2] allows for the evacuation area lighting using indirect luminaires (up-light), and in the design process should be considered only one reflection (no multiple reflections). Another important issue, improving the evacuation process is the use of safety signs, that quantity shall be adjusted so as to locate escape route, emergency exits and equipment such as fire extinguishers, hydrants, first aid kits was easy. In addition, it is recommended that escape route was held by the shortest route from the place of evacuation to a place of safety, therefore, an emergency lighting system should allow location of the event and so control the safety signs to direct them to the nearest emergency exit and places of safety. Currently manufactured lighting equipment does not allow for dynamic change of security character content. Therefore it is proposed to develop evacuation lighting fittings, implementing a dynamic presentation of content (safety signs and text), that uses LCD modules, DLP, LCoS and OLED.

Safety signs, including directional signs shall meet the requirements for the design rules. It is important that the requirements according to PN-ISO 3864-1:2006 "Symbols. Colours of security and safety signs"[10], as well as the requirements of ISO 3864-4, concerning the colorimetric and photometric properties of safety signs were obeyed. PN-EN ISO 7010:2012 additionally regulates the international nature and recognition of evacuation and fire protection signs, and introduces a number of new labels aimed at saving human lives. The PN-EN 1838:2013-11[2] specifies minimum lighting requirements to be met by safety signs illuminated either externally or internally. Pictograms and safety signs, in accordance with ISO 3864-4[10] should have a background colored green (RAL 6032) and the sign of white color. Additionally the background should occupy at least 50% of the safety mark. Luminance of any part of the sign that is white and green colored may not be lower than 2cd/m^2. Uniformity of colored parts of the character described as the ratio of maximum to minimum luminance of the surface of one color, should not exceed 10:1. PN-EN 1838:2013-11[2] also regulates the contrast level of the white and green surface of safety mark. The ratio of the luminance of the white part of the sign to the luminance of the background should be not less than 5:1 and not greater than 15:1 [6]. Taking into account the minimum luminance of the sign in the whole period of its operation, it turns out that the maximum of its value should not exceed 30cd/m^2. This assumption is true only when taking into account the lowest possible luminance of safety mark, which must meet the requirements of standard and do not take into account the decrease in light output over the lifetime of the luminaire. In other situations the contrast range must be observed and design procedures applied, to achieve the satisfactory luminance uniformity.

Concept of construction of escape fittings using LCD modules, DLP,LCoS, OLED, LED

Commercially available emergency and evacuation lighting luminaires use fluorescent light sources and LEDs. The selection of this kind of technology is caused by their high luminous efficiency and a choice of a relatively low power sources and power systems. Emergency luminaires are powered independently or centrally. The most common method of supplying power is autonomous method, using a dedicated energy storage, usually in the form of a battery. Typically, emergency and evacuation lighting operation can be carried out within the range of temperature from 5ºC to 40ºC, with special solutions operating between -25ºC and +50ºC.

A desirable feature of the emergency lighting system is the possibility of presenting the content as pictograms and safety signs. The content of pictograms should be unambiguous, universal but also should allow modification of the content of the sign, depending on the events resulting from the failure. Implementation of the changes of labeling text should be closely linked to the building management system (BMS), in which the emergency lighting system combined with the overall crisis management system plays an important role.

Analyzing the emergency lighting system needs in terms of the content of safety signs modification, it is proposed to use semiconductor emitters LED / OLED, laser and other solutions for dynamic modification of the content presented as LCD and DLP modules or LCoS as modern light sources. In LCDs, liquid crystals are used which additionally cooperate with backlighting systems that use LEDs [3]. The uniformity of the luminance distribution and the so-called "brightness" of the display depends on how the implementation of the backlight is realized. Imaging technique that uses DLP modules (Digital Light Processing) and DMD actuators (Digital Micromirror Device) or LCoS (Liquid Cristal on Silicon) (Figure 1) can also be used for the construction of emergency lighting, but the emission of radiation is the result of reflection of the luminous flux from the single cells (DMD micromirror modules or LCD cells on the mirror substrate).

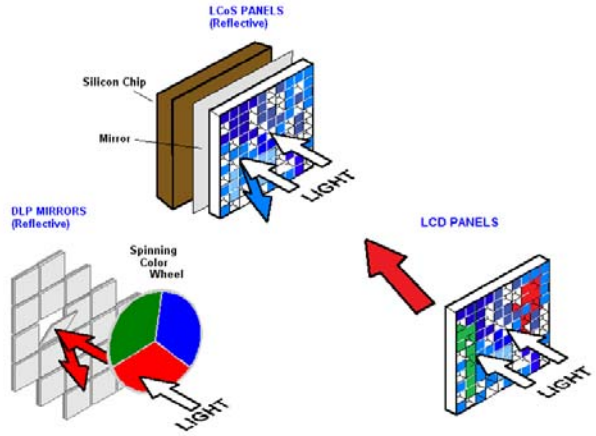

Fig.1. Methods for obtaining the image in LCD, LCoS and DLP technology[4]

LCD and OLED modules and displays are usually technically described by using two parameters: the average luminance and contrast dynamic. Similar parameters apply to the description of the evacuation luminaires, so it is possible use of this type of emitter to work as lighting equipment. In typical devices equipped with the LCD displays average luminance value is ranging from about 100cd/m^2 to about 300cd/m^2. ANSI contrast (white to black) reaches a value of 1:1000 and more (typically 1:800). Assuming that the minimum value of the luminance of the display with security mark will be 200cd/m^2, the green background should have a luminance in the range of 13.33cd/m^2 to 40cd/m^2.On the basis of the study [5], uniformity of luminance does not go below 0.7. For LCoS and DLP modules only applied light source and type of construction of the optical path determines the distribution of luminance.

Taking into account the above assumptions a new construction of escape luminaires with the presentation of pictograms (Figure 2), which will use LCDs or OLED or LCoS or DLP, is proposed. If OLED or LCD module is used as emitter of light that implements presentation of safety mark, the sign should be treated as such internally illuminated. In situations where the presentation of pictograms or other content related to the process of evacuation or fire event will use DLP or LCoS modules, then the sign should be treated as externally illuminated, and the image will be displayed on a special screen or wall surface. This kind of construction, apart from expected spectrophotometric properties, should provide the possibility of by-wire or wireless communication with the master system through optical or radio track. Emergency lighting management system should be based on information obtained from sensors and optical barriers to modify the content of pictograms presented by escape luminaire. Luminaires can work with the central power or autonomously. The evacuation luminaires management and control should allow to log the status of the emergency system and to monitor the work of each luminaire.

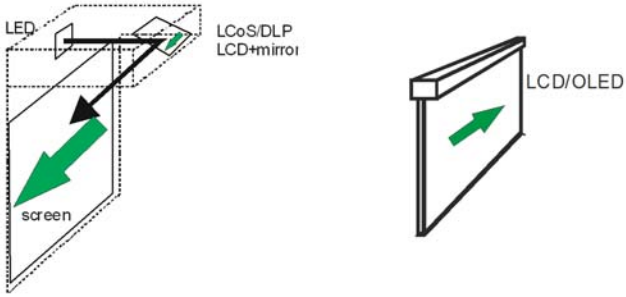

Fig. 2. The concept of evacuation lighting fittings implementing presentation safety mark

Analysis of image displays application conditions for presentation of safety signs

When typical dimensions of commercially available LCD modules are considered it is possible to analyze their location in the evacuation illumination area, taking into account observation distance of the safety sign [2]:

(1) $$L = h \cdot p$$

where:
L – observation distance of the safety sign,
h – height of the sign,
p – constant describing type of illumination of the sign: p = 100 for signs with exterior illumination, p = 200 for signs with interior illumination.

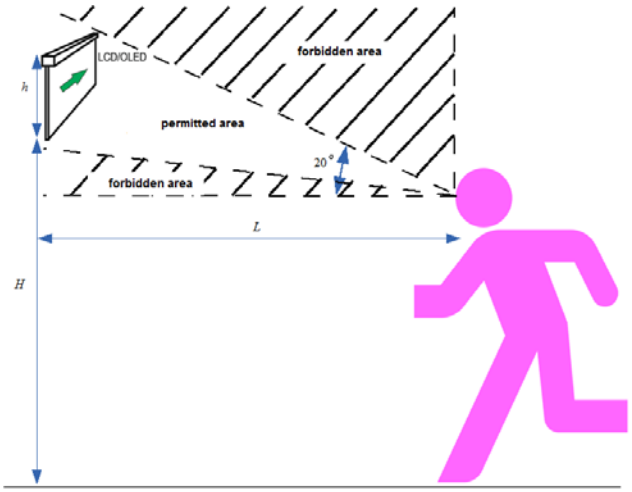

Fig. 3. Geometry of localization of escape luminaire

Due to the fact that the LCD and OLED modules emit luminous flux, constant p = 200, should be used that defines internally illuminated signs. DLP and LCoS modules reflect the luminous flux and direct it to the diffusing screen, so constant p = 100 should be used.

In a situation when the requirements of PN-EN 50172:2005[9] require evacuation lighting and safety signs installation on a minimum height H = 2m, and their visibility determines observation in the angle of view of 20 degrees from the eye level, the distance between evacuation luminaires is strictly determined (Table 1 and 2). The minimum mounting height of the luminaire and observation in a predetermined angle make the field of view can be divided into the forbidden and permitted area, in which it is possible to locate the lighting equipment performing presentation of safety mark (Figure 3). It alsow depends on LCD screen size proportion:4/3 or 16/9 (Table 1 and 2).

Table 1. Geometry of the internally illuminated escape luminaire positioning (p = 200)

Diagonal of the display module	Height of the sign h [m]		Observation distance L [m]	
	4/3	16/9	4/3	16/9
7"	0.10668	0.087157	21.336	17.43137
10"	0.1524	0.12451	30.48	24.90196
15"	0.2286	0.186765	45.72	37.35294
17"	0.25908	0.211667	51.816	42.33333
19"	0.28956	0.236569	57.912	47.31373
22"	0.33528	0.273922	67.056	54.78431
32"	0.48768	0.398431	97.536	79.68627

Tabela 2. Geometry of the externally illuminated escape luminaire positioning (p = 100)

Diagonal of the display module	Height of the sign h [m]		Observation distance L [m]	
	4/3	16/9	4/3	16/9
7"	0.10668	0.087157	10.668	8.715686
10"	0.1524	0.12451	15.24	12.45098
15"	0.2286	0.186765	22.86	18.67647
17"	0.25908	0.211667	25.908	21.16667
19"	0.28956	0.236569	28.956	23.65686
22"	0.33528	0.273922	33.528	27.39216
32"	0.48768	0.398431	48.768	39.84314

According to PN/90-N08000[7] the height of the human line of sight ranges between 1.402m and 1.745m, therefore for the calculations 1.574m above the floor level as the average height is taken into account. On the basis of calculated parameters related to the distance of observation of safety signs it can be stated, that the escape luminaire mounting height H (Figure 3) should not exceed 8m when the LCD emitter is characterized by diagonal 7" and 30m when the emitter has a diagonal of 32" (if the sign is internally illuminated) and respectively shall not exceed 5.5m, when the emitter is characterized by a diagonal 7" and 19m when the emitter has a diagonal of 32".

Conclusions

Emergency lighting systems, including evacuation lighting, are evolving in terms of control and automation. PN-EN 12464-1:2012[8] require on the lighting installation, in addition to complying the photometric parameters, also the implementation of energy efficiency policies, thereby covering the use of modern equipment, coupled with Building Management System BMS, system containing central Danger Management System DMS. Such system is applied in office buildings, industrial buildings and institutions. The scope of its operation includes the integration, control, monitoring, optimization and reporting, inter alia lighting, fire fighting services, alarm, access and supervision systems. Emergency lighting is an essential and required part of a public building and should be implemented on the basis of the most modern lighting equipment, for example using semiconductor emitters.

Aknowledgement

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