Light & Engineering
Vol. 27, No. 4, pp. 93–100, 2019 *https://doi.org/10.33383/2018-156*

MUSEUM LIGHTING: APPROACH, EXAMPLE AND DIRECTION

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ABSTRACT

The article reviews the lighting engineering problems in general to be resolved by lighting installations required for exhibition and museum lighting, as well as the ways to achieve the task while designing the lighting equipment (illustrated by an example of one of manufacturers). Also, as part of the analysis of approaches to resolving of these problems, the major ideas presented in "The Light in the Museum" conference held in St. Petersburg in April, 2018, are described.

Keywords: lighting, lantern, museum lighting, lighting fixture

1. INTRODUCTION

A museum is a place where pieces of culture, history and art are being stored and exhibited. A place where people come to see, to learn something new, something they cannot see every day. It's storage of human memory. People come to museums to understand the cultural and historical periods presented inside of it.

Exhibitions may stay in the visitors' recollection or they may go unnoticed. And it is caused not only by the quality of exhibited works but by the way they are being presented to the visitors. And the light is not the least critical factor here. In fact, it determines everything you see in the museum. Incorrect lighting may distort the colour balance of a piece of fine art. Each exhibit should be lighted individually immersing a visitor into a particular historical and cultural era, influencing a person's emotional perception. For estimation of the quality of museum lighting, it is necessary to take luminous exposure, luminous distribution in the spectator's field of vision into account [1].

Today, there are 3,062 museums in Russia. The total area of Russian museums is 485 thousand hectares. 4 million m^2 of them is the area of museum spaces [2]. Despite the number and significance of these institutions, there are a number of problems in lighting of museums.

Currently, the Government of the Russian Federation pays a great attention to modernisation of museums [3]. It resolves several problems at once. From the one hand, preservation of cultural heritage enriches the nation, promotes patriotic education and love towards homeland and its outstanding people and their art; from the other hand, it promotes development of tourism and redistribution of tourist traffic. It is an important task for the government since the tourism is a powerful driver of economic development and also promotes improvement of the country's prestige. The key for implementation of this task is elaboration of a statutory framework and correct approaches to solving of the existing problems.

The applicable Russian regulations in the field of museum lighting were worked out in the end of the previous century and are to a great extent experimental because the impact of light on materials had not been studied enough by the moment of their elaboration. The recommended light sources (LS) for lighting of exhibits are fluorescent lamps (FL) and incandescent lamps (IL) [4, 5]. For exhibits with medium and low light-resistance, limitations of ultraviolet (UV) and infrared (IR) radiation are to be provided. Therefore, application of

Fig. 1. Example of picture lighting at different values of T_{cc}

Fig. 2. Example of impact of R_a on the quality of picture lighting

FL's becomes limited since light-resistance of exhibits is determined by preservation of colour and physical properties of a material under exposure to LS radiation in the visible part of the spectrum, especially in UV and IR regions. The more intensity of these types of exposure is, the longer duration of exposure to them is, and the less the light-resistance of an exhibit is, the more destructive impact they cause. There are GOSTs [6, 7] regulating determination of resistance of various fabrics/materials against radiation of artificial LSs but all these methods are relevant only for gas discharge types of LSs. Introduction of new semiconductor LSs cause necessity of re-evaluation of these standards to make it possible to elaborate new state-of-the-art standards in the field of museum lighting. Application of ILs has already become inefficient nowadays. Moreover, in 2009, the Law "On Energy Saving and Improvement of Energy Efficiency and on Introduction of Amendments to Particular Legal Acts of the Russian Federation" was adopted. Its major provisions specify prohibition of manufacturing of ILs with capacity of 100W and more. Since the end of the previous century, there has been a great breakthrough in the lighting industry. New efficient LSs, which can resolve a number of problems of museum lighting, has appeared. That's why we have been evidencing a clear trend aiming at reviewing of standards of exhibition lighting in the world today [8]. Primarily, it's definitely the legalisation of application of light emitting diode (LED) LSs. Also, there is necessity of studies relating to positive impact of LED LSs on perception of exhibits and their preservation, which have been being made nowadays. Moreover, there are studies of the limits of possible increase of illumination level using LED LSs which do not impact preservation of materials of exhibits. The results of such studies should become a basis of the updated regulatory documents.

The museum lighting should be designed in accordance with requirements to preservation of exhibits, to comfortable perception, energy efficiency, appearance and usability of a lighting installation (LI).

The glares caused by natural and artificial LSs prevent examination of a picture or of an item inside a case and are one of the most frequent causes of the visitors' dissatisfaction [9]. As a matter of fact, to estimate which type of lighting is suitable for an exhibit, it's necessary to define its exposure limit which depends on chemical composition of paints and materials. There is a general belief that great pieces of art should be perceived in the same way as the author saw them, i.e. with the same lighting conditions as those existing at the moment of creation of the piece of art and available when the first spectators saw it. These conditions could include candles, a kerosene lamp, a campfire light, sunset light or an ordinary incandescent lamp. Of course, in a museum environment, we cannot use the same light source but, with help of modern technologies, we can select a similar one to the most possible extent. Resolving of this problem nowadays requires design of a new LI with chromaticity of radiation selected so that it is similar to the environment in which a painter was creating his work.

Application of LED LSs allows creating and using almost any spectrum of radiation, which allows us to increase aesthetic perception of pieces of art and to improve environment for this perception, which attracts additional visitors to the museum.

Possibility to adjust correlated colour temperature (T_{cc}) of a lighting device (LD) or a group of de-

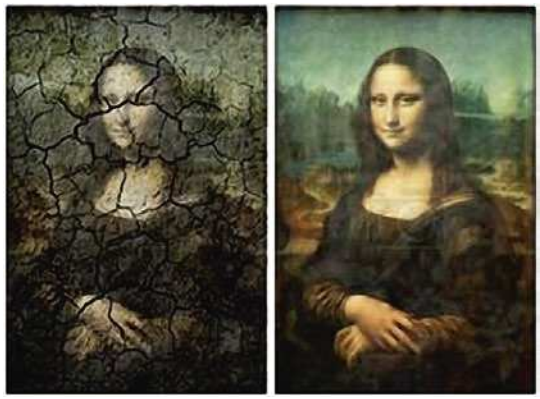

Fig. 3. Example of picture deterioration under impact of UV and IR radiation: left – impact of IR radiation (cracking), right – impact of UV radiation (discolouration)

Fig. 4. *GALAD Aphrodite LED*

vices allows selecting a correct type of tint for each exhibit: warm, neutral or cold (Fig. 1).

And a high value of the colour rendering index (R_a) of at least 95 will allow a visitor to see real colours of a piece of art (Fig. 2).

Wrong selection of the LS may case increase of the speed of degradation of a number of museum exhibits [10]. In particular, UV and IR radiation cause degrading impact on many polymers, fabrics, paper and paintings (Fig. 3). LED LS, with its unique features, is a great option for museum lighting [11]. LED luminaires allow more flexible and delicate management of chromaticity and value of UV radiation, the quantity and direction of heat dissipation from LSs.

One of advantages of LED LSs is high degree of energy saving and low power consumption (PC). Long service life of LED allows us to reduce the scope of electrical installation works for replacing of LSs after their breakdown. If we calculate annual PC of one light source using a gas discharge LS with capacity of 75W and a LED LS with capacity of 20W, both with equal values of luminous flux

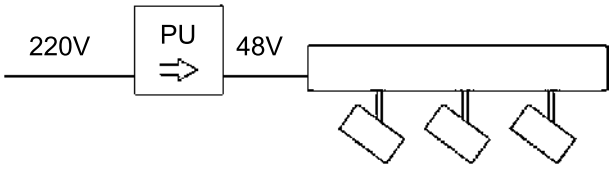

Fig. 5. Example of connection of a group of *Aphrodite LED* luminaires to one power unit

(Φ_v), we'll see that after switching to LED, it will decrease by about 4 times. If we speak about museums where great numbers of LDs are used, such energy saving will turn out to be very sufficient. Therefore, application of LED LSs in LIs under design is preferred rather than traditional LSs [10].

Modern LDs and devices for museum lighting should also comply with architecture and design of premises. In the course of modernisation of LDs, it's necessary to take their own design and usability in account among others. Portability, appearance, economic feasibility, simplicity and usability are important criteria when selecting a LD.

The International Lighting Engineering Corporation BL GROUP has a long-term experience in design of LI for museums. As the specialists of the corporation designed lighting for a number of museums (including the Pushkin State Museum of Fine Arts) using own ideas but foreign equipment in 90's, now we have made the next step forward and have developed a product line of luminaires for museum lighting. In the case of one of them described below, it's clear how many nuances should be considered by a developer when selecting suitable equipment.

2. GALAD APHRODITE LED LUMINAIRE FOR MUSEUMS

Special design, additional modules and options, adjustable parameters allow using of these luminaires for lighting of any exhibitions and to maintain a unified design and management of LI in all halls (Fig. 4).

The museum may have both temporary and permanent exhibitions, and the space of halls may be rearranged. That's why it is necessary to use track luminaires installed on bus ducts. This makes it possible to move the luminaires along the exhibition to form accent lighting correctly. The luminaires may be also fixed to ceilings.

Operating voltage of a bus duct is 48V. It is safe and allows us to install a separate power unit for

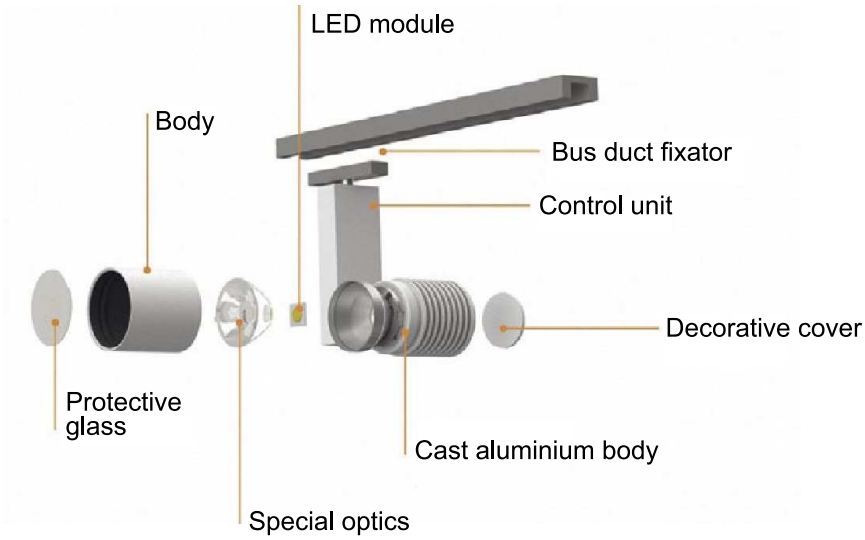

Fig. 6. Structural diagram of the *Aphrodite LED* luminaire

a group of luminaires and avoid application of an *AC/DC*220V power unit for each device, which significantly reduces the size and dimensions of a LI. The weight of one luminaire itself does not exceed 1.6 kg. The power unit of *Aphrodite LED* provides minimal flicker index of less than 1 % and power factor of at least 0.9. There is a capability to connect a group of LDs (Fig. 5).

In Fig. 6, the structure of the *GALAD Aphrodite LED* luminaire is presented:

- The cast aluminium body acts as a radiator for maintenance of an optimal heat mode of the LED operation, and it can rotate 355°×90°, which allows us to direct the LS at different angles and to the opposite side;
- The body of the luminaire may be painted by any colour, which allows us to integrate it into an interior of any exhibition space to make it barely noticeable;
- The LED module by *CREE* with special spectral specifications and high light quality, because there are 5 adjustable LEDs of various colours, which provide to adjust T_{cc} within the range of (3,000–4,000) K, and adjustment of T_{cc} causes no impact to R_a, which remains high, at least 95;
- Special optics (14°, 42° and 52°) does not lead to the colouring of the edges of the illuminated objects (dispersion), and different optics allow us to resolve various tasks of exhibits lighting, floodlight or accent light;
- The protective glass allows us to install filters, which is necessary for protection of exhibits from destructive IR and UV radiation;
- The luminaire has *IP20* protection degree, which maintains protection from hard particles with size more than 12 mm;
- The control unit provides management of the luminaires via the *DMX512* protocol (with support of *RDM* protocol and capability of feedback link), which allows us to assign an original number to each luminaire and control it from the beginning, i.e to monitor its service period, temperature of LED, current, voltage, degrading of a crystal and the most important parameter – the dose in lx hours. All data is saved in a computer and is visible for the maintenance services of a museum.

The special options available for each *GALAD Aphrodite LED* luminaire are presented in Fig. 7.

All options allow us to adjust the size and the shape of a light beam, which provides ability to select the most optimal arrangement of the luminaires so, that they will be almost unnoticeable for visitors and wherein:

- **The lens shade** provides the required angle of shade preventing glare effect;
- **The case** concentrates the light beam, prevents direct lights to the visitors' eyes and improves visual perception;
- **The lens** forms the light beam with required size and clarity;
- **The picture frame** forms the trapezoidal shape of a light spot in order to light the pictures in strict accordance with their contours.

It is significant that all *GALAD* luminaires for museum lighting (Fig. 8) are manufactured in Russia of Russian parts.

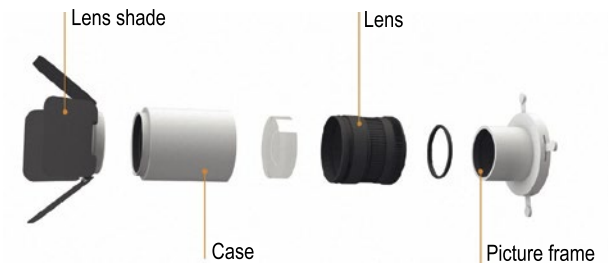

Fig. 7. Additional accessories of the *Aphrodite LED* luminaire

3. PROJECTS ON BASIS OF *GALAD* LUMINAIRES

Nowadays, there have been a number of significant projects implemented using the Russian *GALAD* luminaires, and one of them is rearrangement of lighting in the hall No. 277 of the State Hermitage in the beginning of 2018[1].

Paintings are being exhibited in the hall No. 277. Each painting is unique there, and to select correct lighting, each specific case should be considered individually. But there are some, always to be adhered to, rules:

- At first, the optimal place of examination is being selected, i.e. the point where the visitors will be standing more frequently while examining a painting, because it's much important that the light from a lighting the painting luminaire does not fall on surrounding paintings and does not interfere in examination of them, so for this purpose, the lens shades or special optics are often used (Fig. 9);
- The materials the painting is made of (wood/canvas/paper) and the paints used for it (oil/watercolour/pastel) are significant factors influencing lighting of a picture, for instance, the oil paintings have increased volume due to brush strokes, and if the lighting is arranged incorrectly, the brush strokes form shades interfering in the author's vision;
- Glazed surface of a picture may create overtones and reflections, that's why the light often falls on a picture at acute angle, which allows the overtones to move under a spectator's feet; the angle of incidence of direct light at flat exhibits placed on walls or stands are selected in the range between 45° and 75° to horizon, but in case of angles exceeding 75°, there are shadows of frames on exhibits, textures distorting them; at angles less than 45°, the overtones on exhibits with glazing surface may cause dazzling effect;
- For each painting a specific standard exhibition duration is specified, which is the time period during which the light can fall on it, excess light may cause quick deterioration;
- An annual dose is specified for each picture, which provides relatively acceptable degree of its deterioration;
- In case of permanent exhibitions, the uniform illumination is usually applied in order not to form large contrast with the background and not to interfere in art perception; too dark background decreases light comfort and too light background makes exhibits to be 'lost'; wherein exhibition space gives an opportunity to make experiments and to create bright and contrast accents;
- Maximum allowed illumination level is specified as well, for instance, for water-colours, paper and fabrics, it is 50 lx and for oil paintings, it does not exceed 150 lx [4].

Among distinctions of Hall No. 277, it is important to note the whitened arched ceiling used for formation of the overall illumination by means of reflected light. The previous LI was equipped with fluorescent lamps luminaires (FL). A study conducted by specialists of ILEC "BL GROUP" showed insufficient illumination level of both exhibition and paintings and the space itself, provided that sufficient illumination levels are still not standardised and are specified only in recommendation documents.

It was decided to implement the overall illumination by means of strip luminaires hidden behind the ceiling cornice. The number of luminaires was determined by lighting calculation so that, with consideration of the ceiling reflection, the overall illumination of the hall became compliant with regulatory requirements.

The *Aphrodite LED* luminaires were applied for lighting of the exhibits (Fig. 10). The task included minimal construction interference. In 4 areas approved by the management of the museum, the unique mount fittings designed with consideration of wall materials and the load weight were installed, then a cable was pulled and a bus duct was attached to it. The calculations of the mount fitting, cable material and tension had been made with consideration of allowed slackening and so that it could not affect the luminaires aiming system.

[1] The rearrangement of lighting in the hall No. 277 of the State Hermitage is comprehensively described in [12].

Fig. 8. Product line of *GALAD* luminaires for museum lighting

The type of optics was selected and aiming of the luminaires was performed by the specialists of BL GROUP with consideration of the dimensions of the exhibits, evenness of illumination distribution on the paintings (with gradient taken into account as well). The LED type was determined with consideration of paintings properties and necessity to provide high level of colour rendering.

The specialists of ILEC "BL GROUP" conducted estimation of the object, design, approval and mounting as soon as possible. Now the visitors of the State Hermitage can rate the renewed Hall No. 277.

4. RESULTS OF THE FIRST CONFERENCE OF LIGHT IN THE MUSEUM

The project described above and other similar projects are first stages of the serious modernisation of museum facilities to be performed in the coming years. Given the scale of the targets of the lighting industry, the community of specialists requires coordination of their actions and elaboration of new principles of work in this sphere which has nationwide scale.

That's why the first Light in the Museum conference took place in the State Hermitage in Saint Petersburg between the 18th and the 21st April, 2018. The conference was organised by the State Hermitage, the Scientific and technical Council of the Lighting Industry (NTS SVETOTEKHNIKA) and the Russian Lighting Research Institute named after S.I. Vavilov (VNISI) with support of the Russian Committee of the International Council of Museums (ICM of Russia) and the Union of Museums of Russia.

Representatives of the museum and light industry communities, Russian and foreign specialists in museum lighting presented their reports.

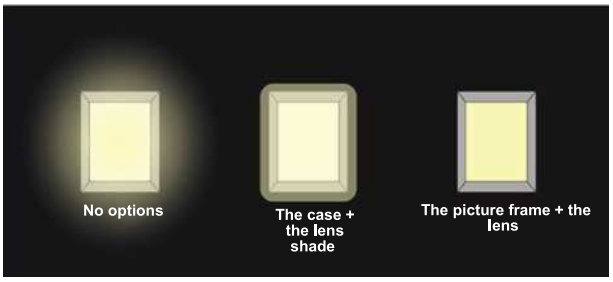

Fig. 9 Lighting options of painting lighting with *GALAD* luminaires

Fig. 10. Location and aiming of track luminaires for painting lighting

The agenda of the conference Light in the Museum was very busy, and the active discussions regarding current challenges in the museum lighting took place during all conference days.

The first and the most significant challenge is necessity of development of a standard specifying requirements to the museum lighting and methods of supervision of compliance with these requirements; it is also required to organise monitoring of parameters of the existing museum lighting LDs applied for lighting of museum entities and to conduct research of the state of museum lighting.

Much has been said that the museum lighting should not only be aesthetically acceptable but also energy saving. Some of the speakers shared their own experience in museum exhibits lighting speaking about challenges they had faced and methods used for their resolving.

After the end of the conference (April 20, 2018), the head of the Association of the Scientific and technical Council of the Lighting Industry (NTS SVETOTEKHNIKA) G.V. Boos and the director of the State Hermitage M.B. Piotrovsky signed the Memorandum of Scientific and Technical Cooperation in the Field of the Museum Lighting in the Council Hall of the State Hermitage.

As part of the conference, the Illumination Equipment for Museum Lighting roundtable of the Light Industry Trading Association (STA) chaired by the Vice-President of STA S.V. Koynov and the president of Lighting Business Consulting V.G. Gabrielyan took place. The question of museum lighting was examined from several practical points of view during the roundtable. A.V. Isaev, the Chief Energy Engineer of the State Hermitage, described the principles and approaches the museum adheres to when creating its own lighting systems. Some reports by representatives of equipment manufacturing companies, e.g. *Philips*, *iGuzzini*, were devoted to specific devices and their advantages. The president of the *Tochka Opory Company* S.N. Kolomiytsev, from the other hand, accentuated individual approaches to design of exhibition lighting and non-standard solutions. The representative of *Erco* company M.A. Berzin spoke not about luminaires but about the types of track systems for their installation. And the marketing director of Trion LED, LLC, T.M. Trishina reported about criteria and tools for illumination evaluation in museums. The representative of ILEC "BL GROUP" examined the question of museum lighting as a whole: not just the exhibition but the surrounding territory, offices, storage rooms… This subject was even more detailed in relation to linked sectors by the Director General of Lighting Business Consulting S.V. Borovkov. His report was called "The Modern Museum as a Factor of Urbanistic, Economic and Social Development".

The main objectives of cooperation are involvement of professionals in lighting of museum resources and preservation of cultural objects as well as carrying out of studies of impact of artificial light on museum exhibits, elaboration of legal framework, quality and safety control of museum lighting equipment and introduction of high-performance light sources for lighting of exhibitions.

All participants of the conference perceive cooperation for achievement of the goals and resolving of existing problems as the main target.

G.V. Boos and M.B. Piotrovsky came to a conclusion the Light in the Museum conference will become traditional and will be conducted biyearly. There is an exhibition of lighting equipment for museum lighting planned alongside with the conference, during which the manufacturers may present their devices and tell about distinctions of their designs and demonstrate their application for different tasks of exhibit lighting. The next Light in the Museum conference is planned to be held in 2020.

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