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INSTALLATION OF LED LIGHT SOURCES

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ABSTRACT
The paper describes the experimental facility, which allowed to carry out studies of influence of light-emitting diode (LED) lighting with different color temperatures and levels of illumination of the working surface on vision organs and the whole body. In the discussed experimental facility one room was designated for examination of observers and three experimental rooms had enclosing surfaces with reflection coefficients specified beforehand (ceiling ρ_c=0.7; walls ρ_w=0.5; floor ρ_f=0.3). In two experimental rooms lighting systems with LED lights were installed and the third one had lighting systems with conventional fluorescent lamps. In the experimental rooms, in order to create necessary level of vertical lightning on the screen with the test object, as well as to measure time of achromatic adisparopia and carry out campimetry, lights were installed on the wall of each room behind and above head of an observer; variants of lighting were simulated using DIALux software. Simulation in DIALux software allowed to develop standard quantitative and qualitative parameters – horizontal illuminance on the working surface, nonuniformity of distribution of lightning and unified glare rating (UGR).

KEYWORDS: LED lighting, lighting conditions, experimental facility, lighting simulation.

INTRODUCTION

Development of energy efficient lighting systems (LS) is one of the topical problems of lighting engineering (Heinz, 2003). One of the ways to address that problem is use of light-emitting diode (LED) sources in LS, which have a number of advantages as compared to thermal and gas-discharge lightning sources: service life can be more than 50 thousand of hours of operation, they are economical, have high energy efficiency (light output more than 100 lm-W (Abramova *et al.*, 2007), high durability and they don't content toxic mercury. Due to small sizes of LED lightning equipment can change direction of lightning flow in space of illumination object (Mikaeva *et al.*, 2014).

However, there are only few studies in Russian and foreign literature on influence of LED on functional condition of organ of vision (Mikaeva, 2004; Mikaeva, 2012). For carrying out of the study conditions of LED lightning an unique general purpose experimental facility (EF) (Zheleznikova *et al.*, 2013) was developed and was installed in the laboratory of the building of FSEI HPE MSU of N.P. Ogarev name. The laboratory consists of four rooms: one is for examination of observers with reflection coefficients of enclosing surfaces (for ceiling ρ_c=0.7; for walls ρ_w=0.5; for floor ρ_f=0.3) and three experimental rooms, two of which has installed LS with LED lights and the third has LS with regular luminescent lights. In the examination room three lighting openings were covered with jalousie with ρ=0.1; the experimental rooms didn't have natural lightning. Height of the rooms was 3 m. Reflection coefficients of ceiling, walls, floor and working surface, correspondingly, were as follows: ρ_c = 0.7; ρ_w = 0.7; ρ_f = 0.3 and $\rho_{w.s.}$ = 0.3. Enclosing and working surfaces of experimental rooms were diffuse-reflecting.

In experimental rooms, in order to create a necessary level of vertical illuminance on a screen with test object for measurement of achromatic adisparopia and on a campimetr on a wall of each room, behind a back of the observer and above his/her head lights were installed.

MATERIALS AND METHODS

For experimental studies lights of the following manufacturers were selected:

- Joint enterprise of Russia and the Republic of Korea – "Nepes Rus" Ltd. (Cap Flat 66-16 LED lights);
- Corp. "Ardatovski lightning factory" (LED lights – DVO12-38-001 Prizma and luminescent lights – LVO04-4x14-041 PRS and LVO04-4x18-041 PRS).

List of the lights selected for the experimental studies is presented in the Table 1.

Table 1. List of lights used in experimental studies

Type of lights	Brief technical characteristics, manufacturer	Type of lightning source, manufacturer
LVO 04-4×14-041 PRS	IP20, prismatic diffuser made from PMMA, T5, starting and control device with DALI protocol, cosφ = 0.99, Corp. "ALF".	Osram FH 14W/830 HE; Master TL5 HE 14W/840, Phillips
LVO 04-4×18-041 PRS	IP20, prismatic diffuser made from PMMA, starting and control device with DALI protocol, cosφ = 0.98, Corp. "ALF"	Osram L 18W/950
DVO 12-38-001 Prizma	IP40, prismatic diffuser made from PMMA, driver device with DALI protocol, cosφ = 0.96, Corp. "ALF".	LED STW8Q14B, Seoul Semiconductor
Cap Flat 66-16	IP 20, "remote luminophor" technology, driver with DALI protocol, cosφ = 0.94, "Nepes Rus" Ltd.	LED, T_{color} = 4094 K "Nepes Rus" Ltd.
Cap Flat 66-16	IP 20, "remote luminophor" technology, driver with DALI protocol, cosφ = 0.94, "Nepes Rus" Ltd.	LED, T_{color} = 3045 K "Nepes Rus" ltd.

RESULTS AND DISCUSSION

Prior to installation of lights in the experimental rooms, lightning options were simulated in DIALux software considering requirements of SP 52. 13330.2011 "Natural and artificial lightning", SanPin 2.2.1/2.1.1.1278-03 "Hygienic requirements for natural, artificial and combined lightning of residential and public buildings" and SanPin 2.2.1/2.1.1.2585-10 Corrections and additions No. 1 for SanPin 2.2.1/2.1.11278-03 "Hygienic requirements for natural, artificial and combined lightning of residential and public buildings" for general lightning of public and administrative buildings. Requirements to the quantitative and qualitative parameters of general lighting in rooms of public and administrative buildings, where are A-2 class of vision operations is carried, which we selected as the basic class, are presented in Table 2.

Table 2. **Normalized quantitative and qualitative parameters lightning environment of main rooms of public and administrative buildings**

Rooms	Plane of lightning normalization (H – horizontal, V – vertical), m	Class and subclass of vision operation	Illuminance of working surface for general lightning, lux	UGR, not more than	Coefficient of illuminance pulsation, not more than
Main rooms of public and administrative buildings	H-0.8	A-2	400	21	10

In order to determine appropriate fields of application of LED lamps in LS of various functions, experimental studies were carried out in three light illuminance: 200, 400 and 1000 lux, which are the most common for visual operations in rooms of various functions (Amel'kina *et al.*, 2013a). Table 3 presents the studied lightning options.

Changing of level of illuminance of a working surface was achieved by means of implementation of regulated starting and control devices and drivers. For all used luminescent and LED lights dimming of luminous flux was carried out using DALI protocol. Brightness of output opening of lights for all lightning options was always equal in a case of the equal illuminance. Simulation of lightning options by means of DIALux software allowed to carry out height of installation of lights, which allows to achieve illuminance at a working surface of E = 1000 lux; other levels of illuminance down to E = 100 lux were set up by means of dimming of luminous flux. Simulation in DIALux software also allowed to create normalized quantitative and qualitative parameters of EF (horizontal illuminance at a working surface, nonuniformity of illuminance distribution and UGR). Psychophysiologic and hygienic studies of conditions of LED lightning on a basis of the designed EF are presented in (Amel'kina *et al.*, 2013b; Amel'kina *et al.*, 2014; Zheleznikova *et al.*, 2014).

Table 3. Studied lightning options

Basic lightning option	Experimental lightning option	Level of illuminance, lux
LVO 04-4×14-041 PRS, T_{color} = 2953 K	Cap Flat 16-66, correlated T_{color} = 3045 K	200
LVO 04-4×14-041 PRS, T_{color} =2953 K	Cap Flat 16-66, correlated T_{color} = 3045 K	400
LVO 04-4×14-041 PRS, T_{color} =2953 K	Cap Flat 16-66, correlated T_{color} = 3045 K	1000
LVO 04-4×14-041 PRS, T_{color} = 3917 K	Cap Flat 16-66, correlated T_{color} = 4094 K	200
LVO 04-4×14-041 PRS, T_{color} = 3917 K	Cap Flat 16-66, correlated T_{color} = 4094 K	400
LVO 04-4×14-041 PRS, T_{color} = 3917 K	Cap Flat 16-66, correlated T_{color} = 4094 K	1000
LVO 04-4×18-041 PRS, T_{color} = 4914 K	DVO12-38-001 Prizma, correlated T_{color} = 5033 K	200
LVO 04-4×18-041 PRS, T_{color} = 4914 K	DVO12-38-001 Prizma, correlated T_{color} = 5033 K	400
LVO 04-4×18-041 PRS, T_{color} = 4914 K	DVO12-38-001 Prizma, correlated T_{color} = 5033 K	1000

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