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# Study of the Lighting Conditions Created by the Second Generation Led Light Sources

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## Abstract

The paper is devoted to the study of the lighting conditions created by the second-generation LED light sources. It has been established experimentally that illumination created by second-generation LEDs does not cause negative effects on human organs of vision and body as a whole. It is shown that changes in the functional parameters of the organs of vision occurring during the performance of visual work fall within the respective limits of physiological fluctuations and are reversible. Integral lighting efficiency indicators of the second generation LEDs by visual performance and the degree of visual fatigue are estimated. The practical significance of the results obtained is shown.

## Keywords

*Second Generation LEDs, Experimental Lighting Installation, Visual Performance, Visual Fatigue, Lighting Efficiency.*

## Introduction

The high growth rate of the LED products market contributes to their widespread use due to significant energy savings and lower operating costs. However, a primary feature of the radiation created by modern white LEDs is significant radiation flux intensity in the blue part of the spectrum. This fact causes a wide range of opinions in the scientific community on the medical and biological aspects of the LED radiation effects on the organs of vision, psycho-physiological state and general physical health of a person [1-3]. In fact, the results of foreign work in this area are used in practice of LED lighting application in Russia.

At present, the second generation white LEDs have appeared on the market, the development of them is aimed at reducing possible photobiological hazard to vision, since their spectrum is close to the solar one [4-5]. It can be assumed that second-generation LEDs will not be as dangerous for the organ of vision as some experts believe. However, this is possible to prove only on the basis of the conducted experimental studies. In Russian and foreign literature sources, there are data only concerning a few research results on the effect of first-generation LED lighting on certain vision functions and visual performance, and those results are extremely contradictory and ambiguous. This gives grounds to consider the studies performed as relevant.

The purpose of this work is a comprehensive assessment of the efficiency of illumination created by second generation LEDs (ILED), taking into account the state of the organ of human vision, and integrated indicators of visual performance.

## Methods

The analysis of existing methods for determining individual indicators made it possible to choose the most adequate ones to the set task: to assess the effectiveness of the light conditions created by LEDs when performing visually strained work. We developed and used in this experiment a comprehensive method for assessing the influence of the LED light condition on the indicators of the state of the organ of vision and the human body as a whole; the method is described in detail in [8-10].

## Main Part

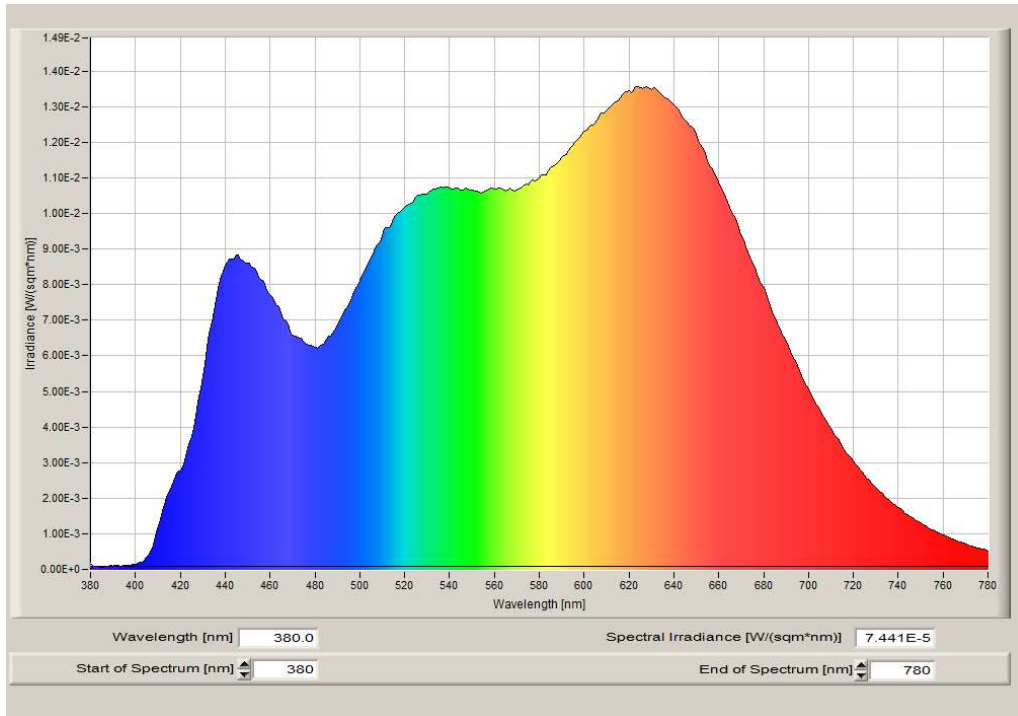
An experimental lighting installation was designed and installed (Fig. 1) for laboratory research purposes. The reflection coefficients  $\rho$  of the enclosing surfaces of the ceiling, walls and floor of the research premises were 0.7; 0.5; 0.3, respectively; the reflection coefficient of the working surface - 0.3. The enclosing and working surfaces of the rooms were diffusely reflective.



**Figure 1: Experimental Lighting Installation**

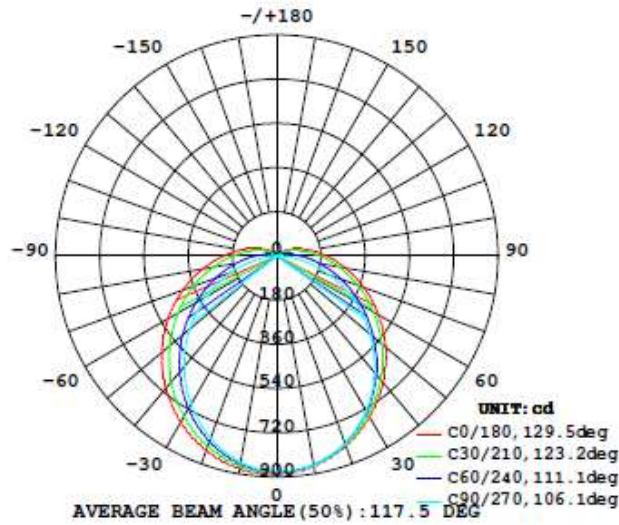
For experimental studies, an experimental pilot lamp with second generation LEDs was manufactured by Ardatovsky Lighting Engineering Plant OJSC. As a base version (for comparing lighting options), we used a luminaire with fluorescent lamps (FL) of the type LVO 04-4 × 14-041 PRS of the same manufacturer.

We have measured photometric and spectrorimetric parameters of the selected fixtures in the Multiuser Center "Lighting Engineering Metrology" FSBEI HE "MSU named after N.P. Ogarev". Figs. 2-4 represent the emission spectrum, light intensity curves (LIC), and the values of the color rendering indices of the LED luminaire.

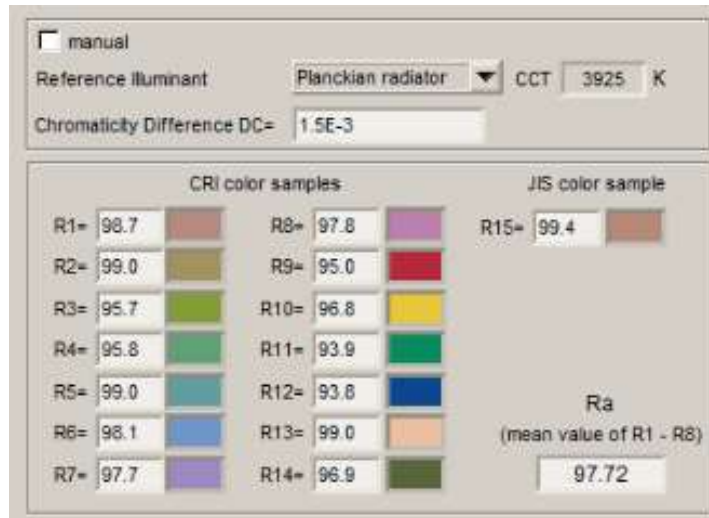


**Figure 2: The Emission Spectrum of the Experimental Lamp with Second-Generation LEDs**

**LUMINOUS INTENSITY DISTRIBUTION DIAGRAM**



**Figure 3: LICs of the Experimental Lamp with Second Generation LEDs in Four Meridional Planes**



**Figure 4: Special and General Color Rendering Index of the Experimental Lamp with Second-Generation LEDs**

Experimental studies were conducted at two levels of illumination E - 500 and 1000 lx. The change in level E was achieved respectively by using a starter-controlled device and control devices regulated according to the “DALI” protocol. Before the experiment, the lighting options were modeled in the DIALux program in order to verify the requirements imposed by [11] (Table 1).

Visual performance	Illumination normalizing plane (H–horizontal, V -vertical), m	Illumination of the working surface upon general lighting, lux	Unified glare rating ( <i>UGR</i> ), not more than	Flicker percent,%, not more than
High accuracy performance of III category according to SP 52.13330.2016	H-0,8	500	25	15

**Table 1: Standardized Quantitative and Qualitative Indicators of the Light Environment of Industrial Premises.**

Work with metal products characteristic of the electric-lamp industry for duration of 90 min was chosen as a model of visual performance. The functional load was to identify defects (quality control) and to sort metal products (current inputs made of various metals and alloys). Work for 90 minutes using the selected model is equivalent by visual fatigue to real working conditions for an eight-hour working day.

10 observers selected for the experiment from among volunteer students aged 20–25 years shown the following results: the refraction was mainly emmetropic; visual acuity in both eyes - 1.0; color perception without pathology.

The procedure of one experiment was approximately as follows: adaptation to the lighting conditions for 15 minutes; measurement of the critical flicker frequency (CFF), the time threshold of achromatic adisparopy, the nearest point of clear vision, diastolic and systolic blood pressure and heart rate; working with correction tasks; one-and-a-half-hour visual work; re-measurement of vision and blood pressure; filling of subjective assessment questionnaires.

Let's consider the individual results of experimental studies.

Statistical processing of absolute accommodation scope research results (AAS) showed that in the compared lighting variants, shifts in AAS values were not reliable ( $p < 0.05$  by Student's t-criterion), therefore, the accommodative-muscular system illuminated by second-generation LED light sources was no worse than when illuminated by FL (LFL).

Studies devoted to the state of the central organ of vision core before and after work according to the CFF method did not reveal the most preferable lighting option: Student's t-test did not confirm the significance of differences at the studied levels of E. The decrease in CFF during a laboratory experiment was associated with the visual work being done; this process is reversible - by the beginning of the next day, the indicators were restored to their original values. That is, under conditions of illumination by second-generation LEDs, a suppressive effect on the state of the central nervous system was not detected.

Visual performance indicators (performance and quality of work) were determined by the following indicators: the testing time and the number of errors made during the test, respectively; the KPFC-99M PSYCHOMAT complex for psychophysiological studies has been used (Table 2).

E, lx	Statistics indices, seconds				Significance of differences by Student's t-test
	Before work		After work		
	VP, s, $\bar{x}$	Confidence interval $t\sigma_{\bar{x}}$	VP, s, $\bar{x}$	Confidence interval $t\sigma_{\bar{x}}$	
500	99.71	10.04	101.55	5.28	<0.05
1000	103.57	17.03	105.50	10.46	<0.05

**Table 2: Visual Performance (VP) in the Conditions of Illumination by Second-Generation LEDs**

A comparative analysis of the data in Table 2 allowed us to state their identical qualitative character: the visual performance rate was significantly reduced in the process of work for an hour and a half. An increase in the illumination level from 500 to 1000 lx did not lead to an increase in the visual performance rate. An assessment of the significance of differences obtained for the visual performance rate (according to Student's t-criterion) at different levels of illumination showed that the difference is random, since the significance level is  $p > 5\%$ .

With the growth of visual fatigue in the process of one and a half hours of work, the number of errors increased. So at E = 500 lx, the performance quality decreased by 62.8%, at E = 1000 lx - by 55.4%. As for the comparison of performance quality indicators at different levels of illumination, at E = 1000 lux before the work the number of errors was 2.6% less than at the level E = 500 lux, and by 7.6% less after work, but Student's t test has not confirmed the validity of these differences. That is, the optimal level E for works of IIIa category in the case of the use of second-generation LEDs is no higher than 500 lux.

### Summary

It should be emphasized that the work on the hygienic evaluation of lighting installations with second-generation LEDs requires continuation.

### Conclusion

An analysis of the results showed that the second-generation LED illumination does not cause a negative effect on organs of vision and indicators of visual performance (age group 20-25 years). Studies carried out under different lighting conditions (LED and FL) revealed both the close connection of the visual functions with the compensatory-adaptive reaction of the organism, and the stability of adaptive systems and systems responsible for regulating the sensitivity of the organ of vision and the organism as a whole. The results of the studies can be used to develop practical recommendations for implementation of second-generation light emitting diodes.

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### References

1. Lyons, L., 2011. LED-based products must meet photobiological safety standart: part 1 // LEDs magazine. V.46: 31.
2. Rea, M.S., Figueiro, M.G., Bullough, J.D., Bierman, A, 2005. A model of phototransduction by the human circadian system. Brain Research Reviews. 20 V.50: pp. 213 – 218.
3. The True Knowledge about White LEDs and Biological Clocks, 2011. LED professional Review. V. 28: 22.
4. TRI-R Technology. Cop.2015 URL: <http://trir-pj.com/en/technology>
5. Seoul Semiconductor. «SunLike» Series LEDs. Cop. 2017. URL: <http://www.seoulsemicon.com/en/technology/Sunlike>
6. Zheleznikova, O. E., Sinitsyna, L.V., 2015. Metodological grounds of study of light-emitting diode illumination effectiveness. International Journal of Applied Engineering Research. 10(24): pp. 44915-44919.
7. Zheleznikova, O. E., Sinitsyna, L.V., Mikaeva, S. A., 2015. To the problem of hygienic efficiency of LED lighting facilities. Biosciences Biotechnology Research Asia. 12(3): 2373-2382.
8. Zheleznikova, O. E., 2015. Determination of led lighting effectiveness on visual performance and visual fatigue degree. International Journal of Applied Engi-neering Research. 10(12): pp. 31463-31469.
9. Zheleznikova, OE, Amelkina, S. A., Sinitsyna, L. V., Kiryukhina, S. V., 2013. Natural and technical sciences. No. 5 (67): p.249-257.
10. SP 52. 13330.2016 "Natural and artificial lighting."