

Analysis of the Local Lighting Fixtures Transition in Ukraine to Led-Analogues Based on a Comprehensive Study of their Light Distribution

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Article History

Received:
29 December 2021

Accepted:
20 April 2022

Published online:
29 April 2022

Keywords

Local Lighting Fixtures;
Light Distribution;
Horizontal and
Vertical Isoluxes;
Light Intensity Curve

Abstract

The purpose of this paper is to study the state of the problem of transition of local lighting fixtures in Ukraine to LED counterparts. At present, there is almost a complete abandonment of the use of traditional light sources, due to the low light output of these sources, low service life, environmental considerations, and so on. However, the main requirement for lighting fixtures of any type is the compliance of their light distribution with the visual tasks that will be assigned to them during operation. As for most outdoor and indoor lighting fixtures, they are, in fact, certified, and their light distribution is given in one form or another either in the passports of the device, or in technical descriptions of relevant products on the websites of manufacturers or in catalogs. As for local lighting fixtures – table lamp fixtures, such information is not provided to the buyer. However, there are generally accepted recommendations for the light distribution of such lamps. Namely - the light distribution should be uniform and direct illumination on the work surface should be close to 200 lux. If you deviate from these requirements, the consumer may face problems such as visual impairment and stooping. As the volume of production of local lighting fixtures is significant, the authors set themselves the task of understanding whether modern models of these fixtures meet these standards. The paper presents data on the systematic study of the light distribution of local lighting fixtures for a considerable period of time. It is shown that the first samples of LED lights did not meet the requirements for their light distribution, which was confidently provided by lights based on compact fluorescent and halogen lamps. But gradually the light distribution of LED-lights approached the cosine and today for the vast majority of LED local lighting fixtures on the market it can be stated that their light distribution is absolutely adequate and further use of traditional light sources for local lighting can be completely stopped. It is also noted that the vast majority of modern table lamps are equipped with dimmers, what allows to flexibly adapt local lighting modes to solve specific visual problems in addition to other energy savings.

INTRODUCTION

At present, LED lighting is actively occupying various market niches of the lighting industry [1–22]. In a previous [15] work, we investigated the impact of LED technology on the range of modern ceiling light fixtures. It was determined that for a long time, Armstrong-type ceiling lights were inferior to "traditional" analogues with fluorescent lamps (FLs) due to non-compliance with the cosine light distribution provided by previous FL designs as in matt diffuser lights (in the early 2000s), and in raster lights with FL (approximately 2005–2010). Modern designs of LED

ceiling lighting fixtures, and especially their panel versions [15], finally decided the direction of further development of the range of these lights – focusing exclusively on LED technology. In this paper, we aim to trace the situation in the market of local lighting fixtures in Ukraine, which is a significant share of the total market of lighting equipment. This work is the final analysis of numerous experiments with relevant industrial designs of lighting fixtures for a significant period of time.

PERIOD 2010 – 2011

In Fig. 1 two fixtures for local lighting are shown the

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Cite as: Lobanov, Y., & Petchenko, G. (2022). Analysis of the local lighting fixtures transition in Ukraine to Led-analogues based on a comprehensive study of their light distribution. *Lighting Engineering & Power Engineering*, 61(1), 1–9. <https://doi.org/10.33042/2079-424X.2022.61.1.01>

only structural difference of which is the upper part of the housing. In the first table lamp, it was used to mount a compact fluorescent lamp (CFL), in the second - it was the basis for the installation of LED points.



Figure 1. General view of two identical designs of table lamp fixtures for CFLs and LEDs

To conduct an experiment for studying the light distribution of these samples we used standard equipment – a horizontal plate with a grid of polar coordinates, fasteners for fixing the luminous surface at different heights and a luxmeter.

The processing of the experiment was unusual – after measuring the horizontal and vertical isoluxes, which gave us an idea of the photometric body of light surfaces, we calculated light intensity curves (LIC) of light intensity of lighting fixtures (due to the known geometry of the light body when measuring illuminance at calculated points of light field).

The data were processed in the program Origin 6.0, which allows us, in addition to graphical visualization of the experimental results, to describe experimentally obtained dependences by analytical laws in the form of, in particular, polynomials of different orders.

The results of the experiment with the studied samples of lighting fixtures are shown in Fig. 2 and Fig. 3.

From Fig. 2 it can be seen that the LIC of the light of local lighting fixture based on CFL fully meets the requirements for such lights [23], namely, the light distribution is uniform, close to cosine, direct illumination in the horizontal plane is approximately 200 lux (according to our calculations it is 97 lux at a distance of photometry 1 m).

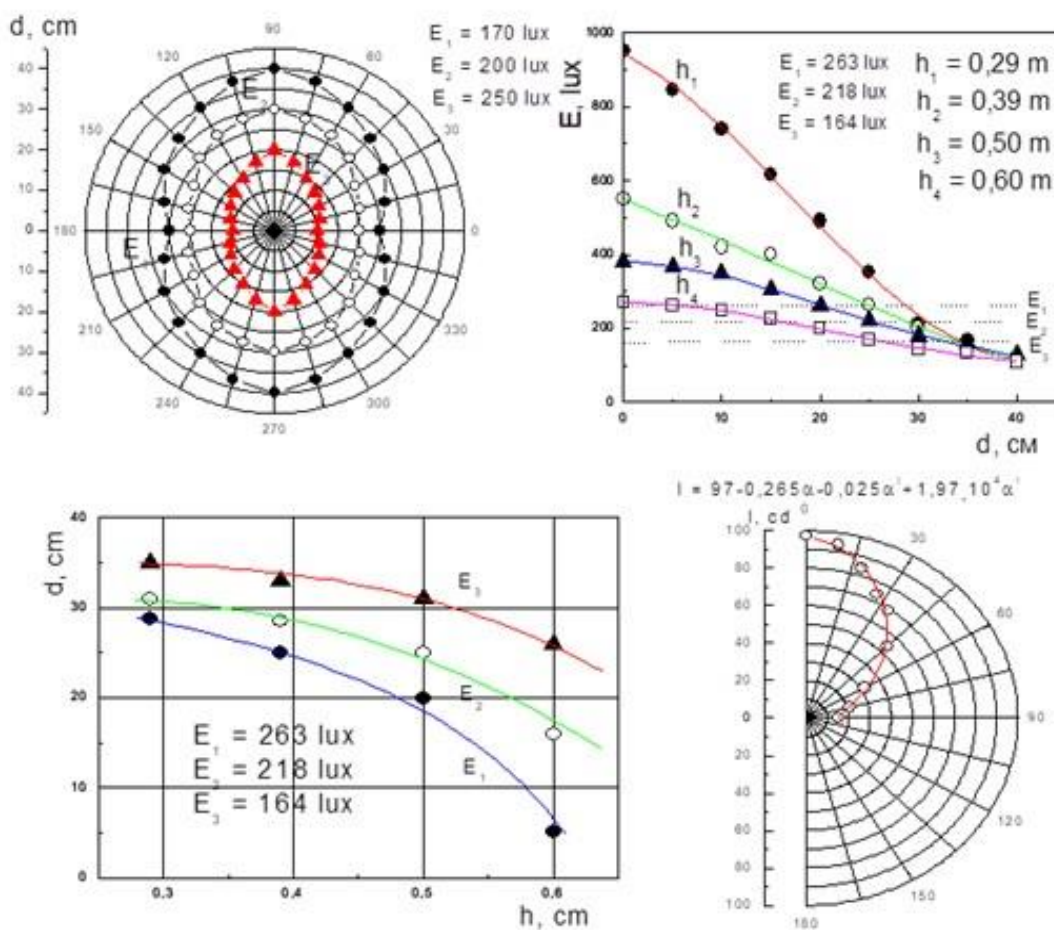


Figure 2. The results of the study of the light distribution of the lighting fixture with CFL: horizontal isoluxes, elementary illumination curves, calculated vertical isoluxes and the curve of light intensity in graphical and analytical form

This compliance with the norm ensures the performance of visual work of varying complexity without eye fatigue and back strain during operation of the lighting fixture. In addition, the uniformity of lighting in the horizontal plane does not contribute to the contrast of the light spot, which adversely affects human vision - in a fairly large area of the work surface, such as the desktop surface in the office, lighting changes slowly and is approximately 150-200 lux. which is, in our opinion, quite acceptable.

A completely different picture is observed for the LED counterpart. The results of the experiment with the corresponding sample are shown in Fig. 3.

From Fig. 3 we can see that the LIC of the lighting fixture with LEDs resembles a "needle" - illumination at the "tip" ~ 340 lux and a rapid decline to zero within angles of 0-15 degrees, which is acceptable for floodlights, but not - for home appliances of local lighting.

This non-compliance of light distribution with the norms for local lighting attracted our attention and in

the future, for a considerable period, we conducted similar research on modern designs of local lighting fixtures.

PERIOD 2011 - 2021

This period is affected, in our opinion, by three main features.

First, there is a trend towards the production and sale of local lighting fixtures with "traditional" light sources, such as the Brille SL-07 GREEN lighting fixture with a 40-watt halogen lamp.

Secondly, the range of LED lighting fixtures is significantly expanding, the light distribution of which is, in our opinion, impeccable.

Thirdly, in local lighting fixtures the dimming option appears to dim the illuminance by both discrete and smooth dimmers. The results of our research are illustrated by the data shown in Fig. 4-10. You can be sure that all LED lights of this period fully meet the requirements for local lighting fixtures.

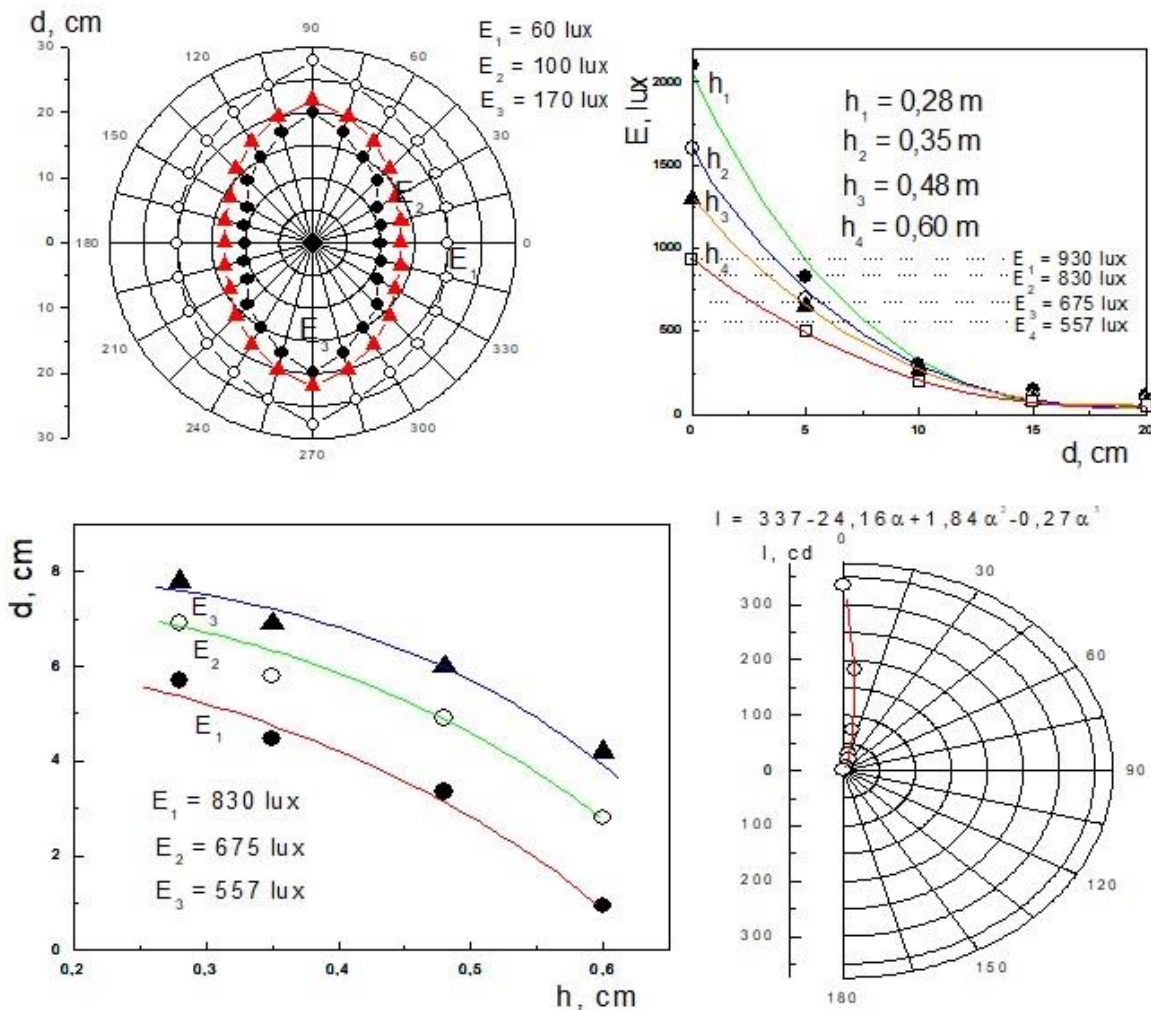


Figure 3. The results of the light distribution study of the lighting fixture with LEDs: horizontal isoluxes, elementary illuminance curves, calculated vertical isoluxes and the curve of light intensity in graphical and analytical form

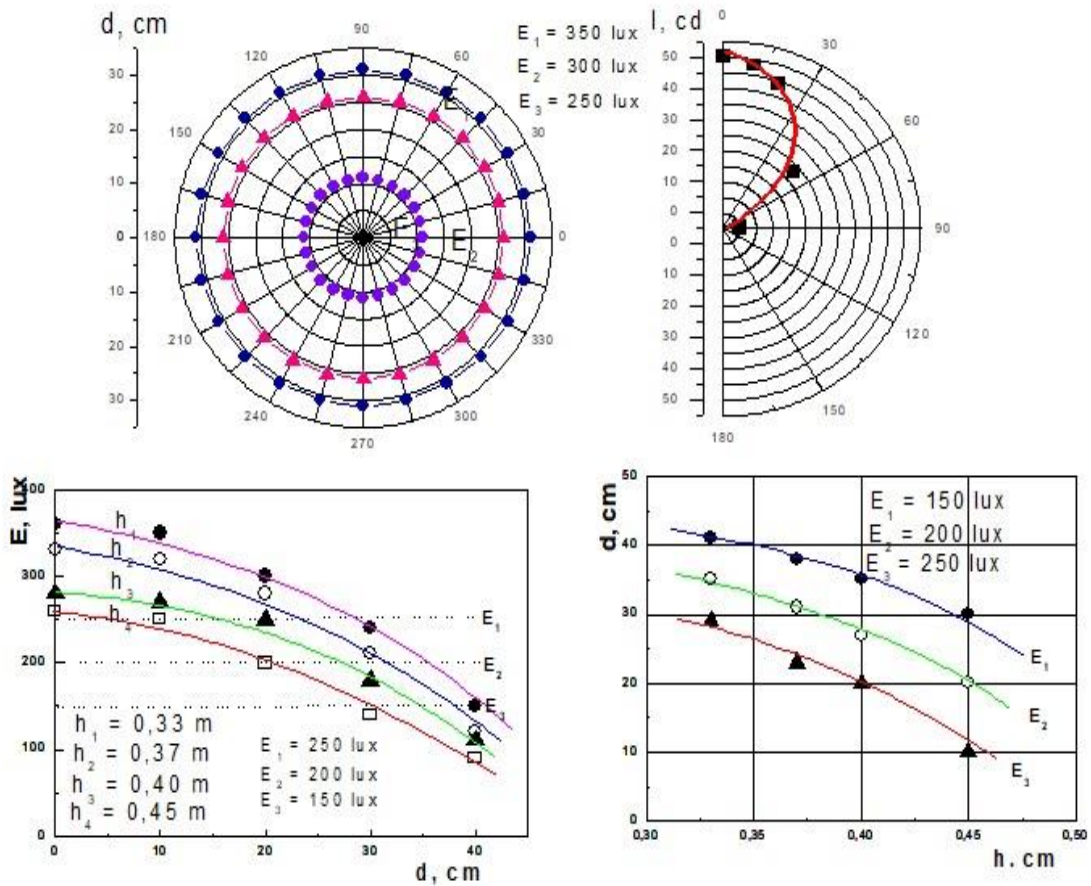


Figure 4. The results of the study of the light distribution of the table lamp Brille SL-07 GREEN with a halogen lamp 40 W: horizontal isoluxes, elementary illuminance curves, calculated vertical isoluxes and light intensity curve

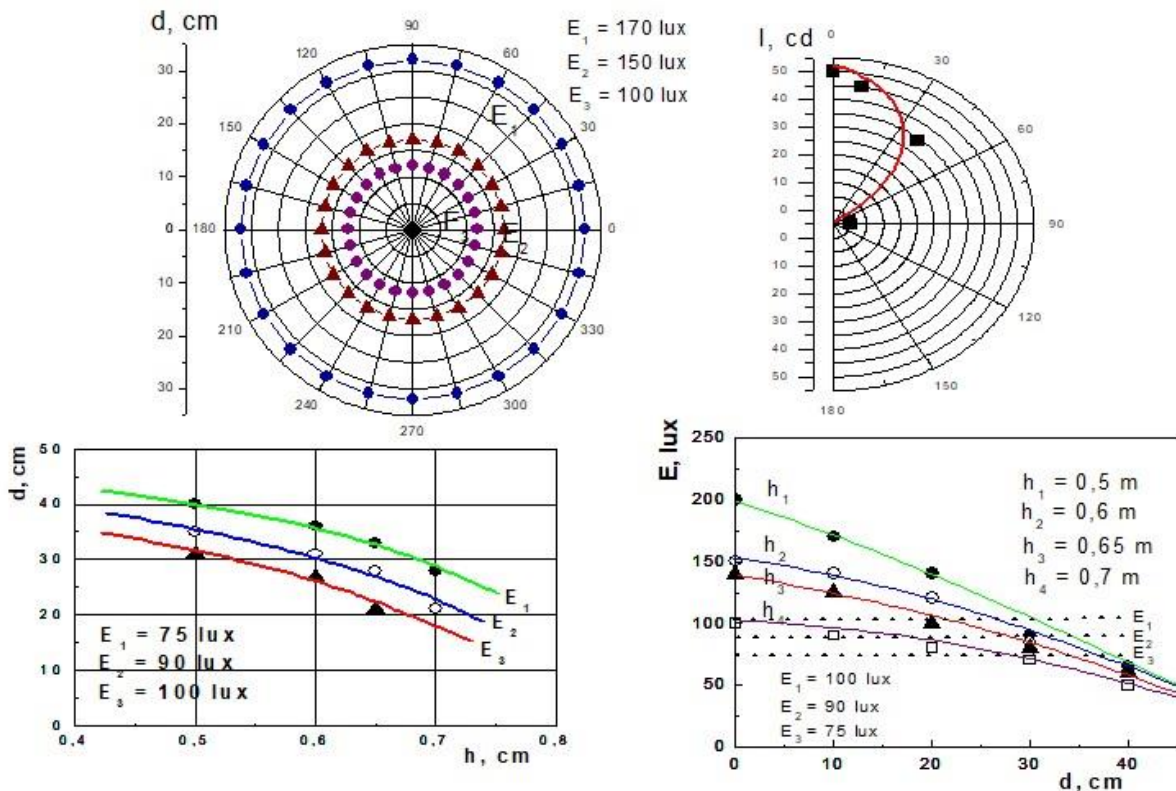


Figure 5. The results of the light distribution study of the LED table lamp HAMELEON KD-760: horizontal isoluxes, elementary light curves, calculated vertical isoluxes and light intensity curve

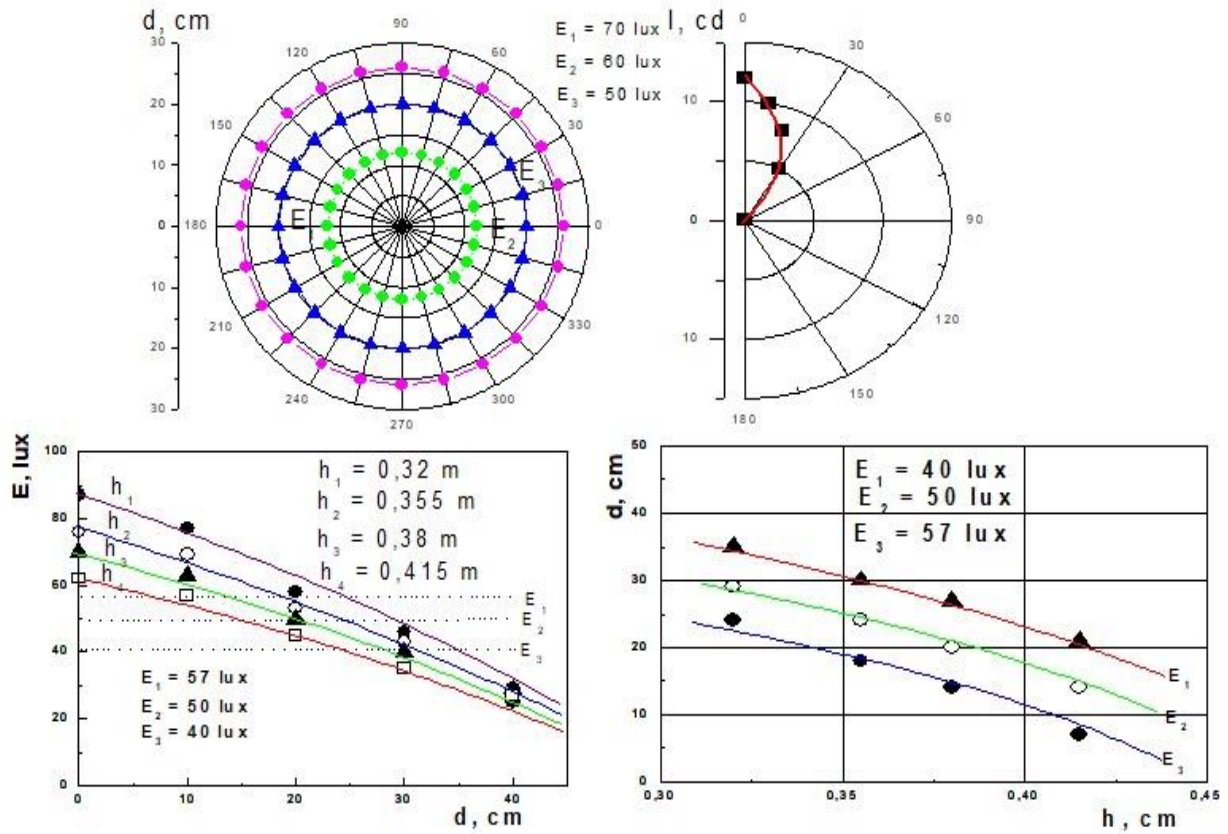


Figure 6. The results of the LED table lamp SL 35 LED study: horizontal isoluxes, elementary light curves, calculated vertical isoluxes and light intensity curve

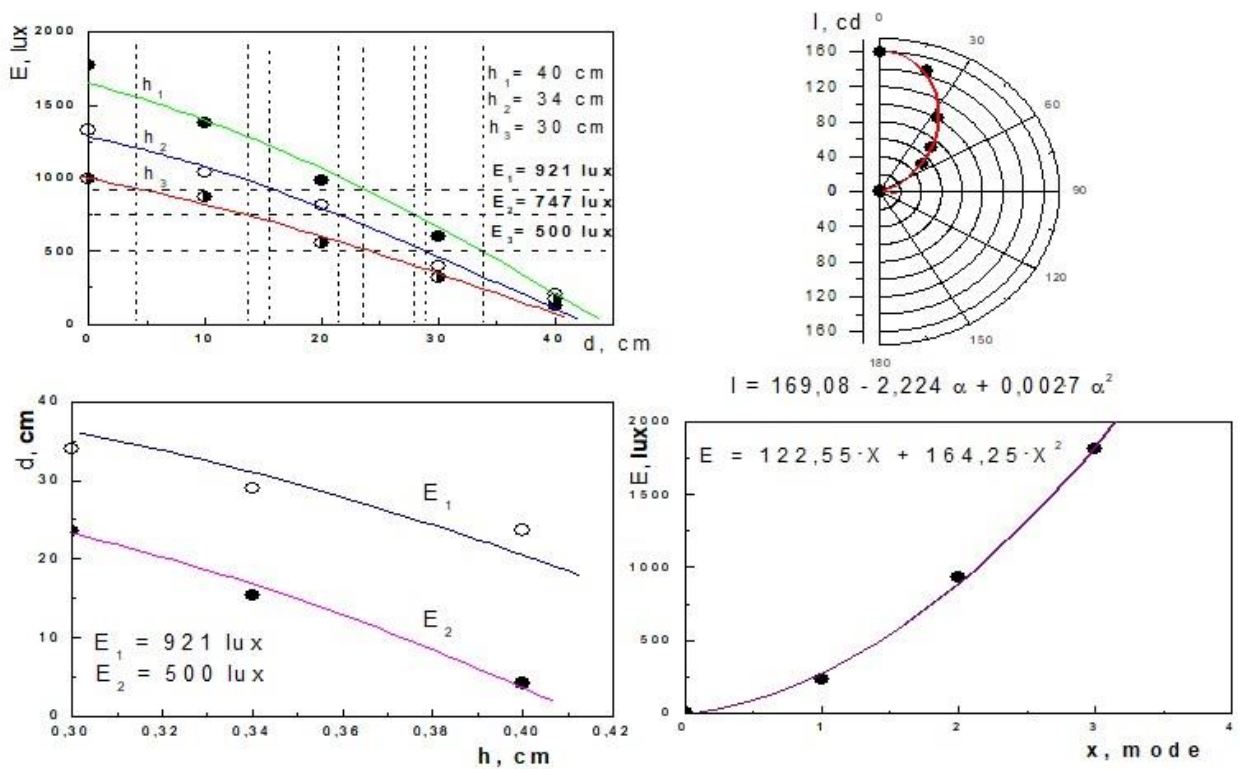


Figure 7. The results of the LED table lamp WT 035 study: elementary illuminance curves, calculated vertical isoluxes, light intensity curve, illuminance of the light fixture in different dimming modes

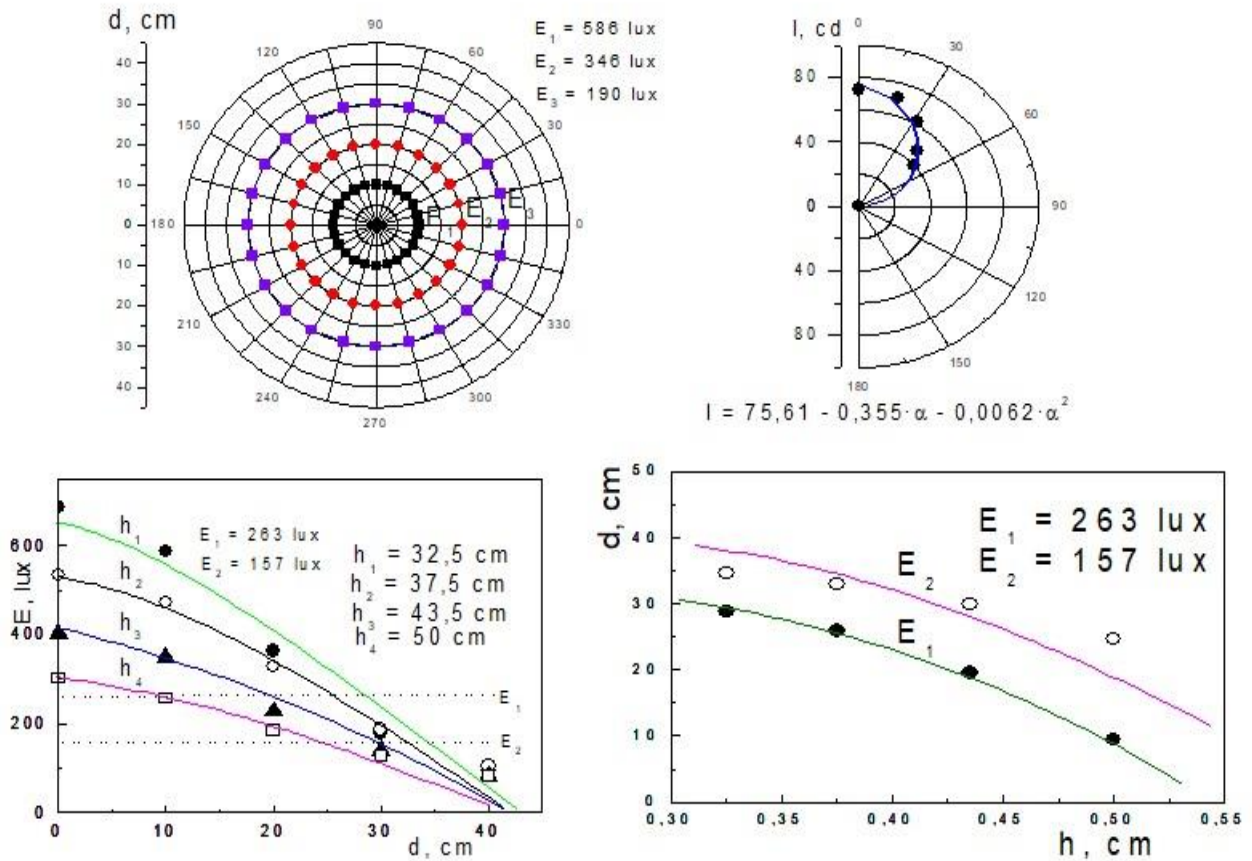


Figure 8. The results of LED table lamp WT 036 5W study: horizontal isoluxes, elementary illumination curves, calculated vertical isoluxes and light intensity curve or light

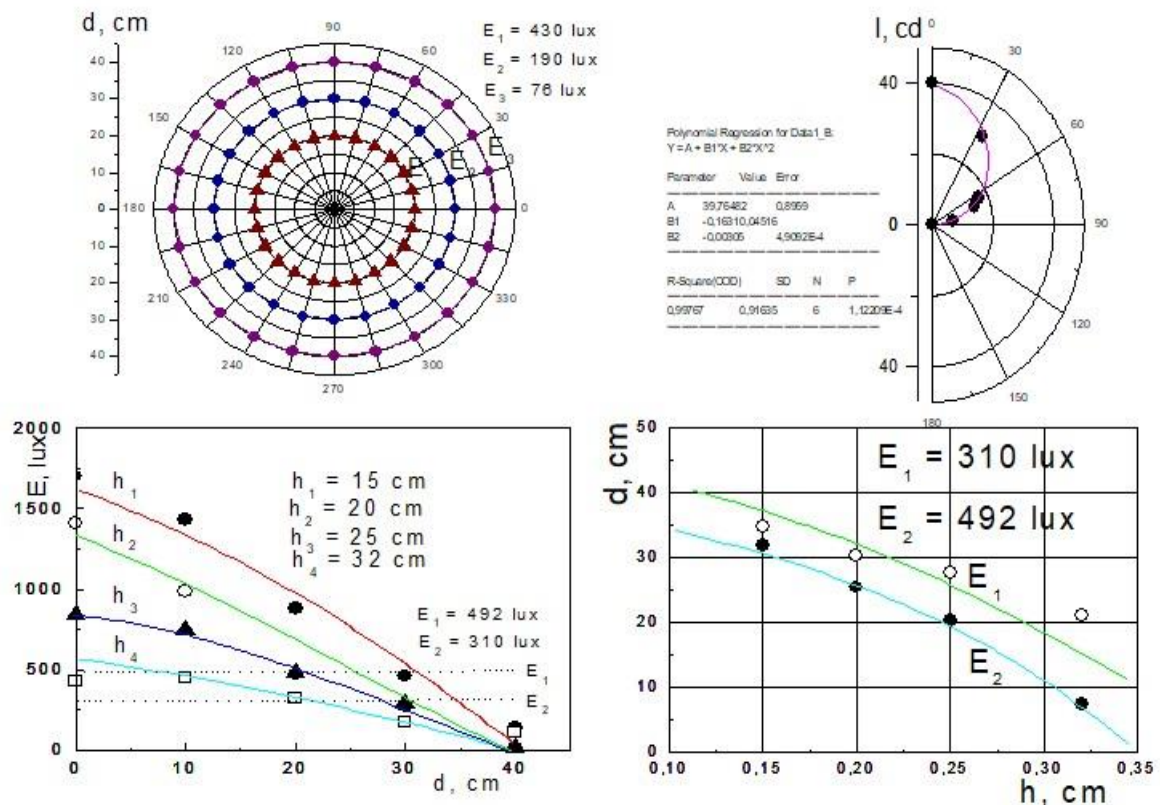


Figure 9. The results of children's LED table lamp Led Brille 4.5 W study: horizontal isoluxes, elementary light curves, calculated vertical isoluxes and light intensity curve

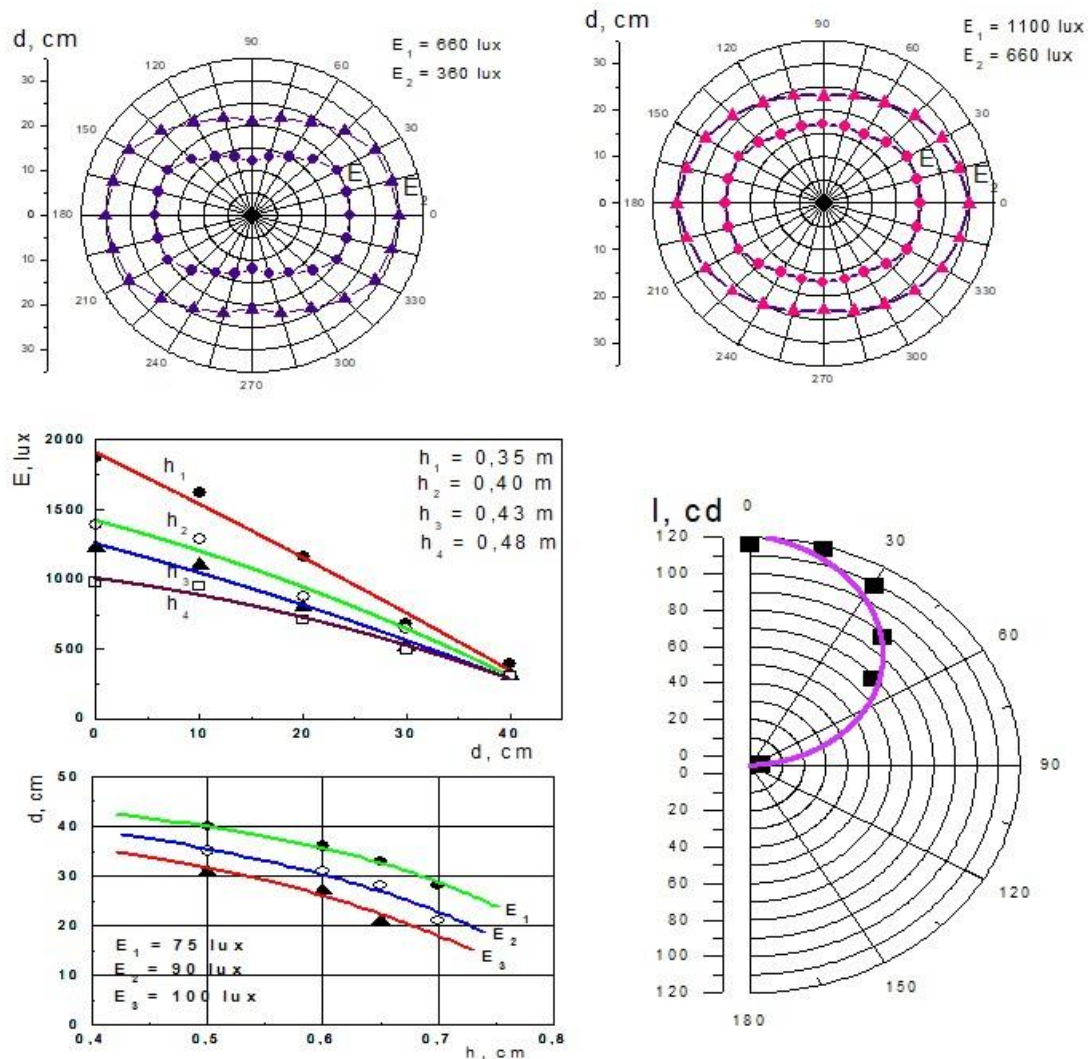


Figure 10. The results of LED table lamp HO9190002 study: horizontal isoluxes, elementary illumination curves, calculated vertical isoluxes and light curve

CONCLUSIONS

As a result of this work, the following conclusions can be drawn. The transition of local lighting fixtures to light diodes can be considered entirely and successfully completed. Today, traditional light sources are almost completely supplanted by their more attractive LED counterparts. At the same time, the energy efficiency of LED local lighting fixtures is accompanied by their fully adequate light distribution, which meets the requirements for lighting fixtures of this type. At the same time, modern designs of LED lighting fixtures are equipped with dimmers, which allows not only to save additional energy, but also to smoothly adjust the level of illumination for specific tasks of visual work.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author(s).

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Аналіз переходу світильників місцевого освітлення в Україні на Led-аналоги на основі комплексного дослідження їх світлорозподілу

Євген Лобанов, Гліб Петченко

Анотація. Метою даної роботи є вивчення стану задачі переходу світильників місцевого освітлення в Україні на світлодіодні аналоги. На сьогоднішній час спостерігається практично повний відхід від використання традиційних джерел світла, що пов'язане з низькою світловою віддачею цих джерел, незначним строком служби, екологічними міркуваннями тощо. Тим не менш, головною вимогою до світлових приладів будь-якого типу, залишається відповідність їх світлорозподілу тим зоровим задачам, які до них будуть ставитись у процесі експлуатації. Щодо більшості приладів зовнішнього і внутрішнього освітлення – вони, фактично, атестуються, і їх світлорозподіл наводиться у тому чи іншому вигляді або в паспортах на прилад, або у технічних описах відповідної продукції на сайтах підприємств-виробників чи у каталогах. Що ж стосується світлових приладів місцевого освітлення – настільних світильників, то така інформація покупцю не надається. Тим не менш, існують загально визнані рекомендації щодо світлорозподілу таких світильників. А саме – світлорозподіл має бути рівномірним і пряма освітленість на робочій поверхні має бути близькою до 200 лк. При відхиленнях від цих вимог споживач може стикнутися із такими проблемами, як псування зору і ступість. Зважаючи на те, що обсяги виробництва світильників місцевого

освітлення є значними, автори поставили перед собою задачу розібратися, чи відповідають сучасні зразки вказаних світильників зазначеним нормам. В роботі наводяться дані щодо систематичного дослідження світлорозподілу світильників місцевого освітлення за досить значний період часу. Показано, що перші зразки світлодіодних світильників абсолютно не задовольняли вимогам щодо їх світлорозподілу, який впевнено забезпечували світильники на основі компактних люмінесцентних і галогенних ламп. Але поступово світлорозподіл LED-світильників наблизився до косинусного і на сьогодні для переважної більшості світлодіодних світильників місцевого освітлення на ринку можна констатувати, що їх світлорозподіл є абсолютно адекватним і подальше використання традиційних джерел світла для задач місцевого освітлення можна повністю припиняти. Також відзначається, що переважна більшість сучасних настільних світильників оснащена дімерами, що, крім додаткового енергозбереження, дозволяє гнучко адаптувати режими місцевого освітлення для вирішення конкретних зорових задач.

Ключові слова: світильники місцевого освітлення, світлорозподіл, горизонтальні і вертикальні ізолюкси, крива сили світла.

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