Light & Engineering
Vol. 27, No. 6, pp. 82–87, 2019 *https://doi.org/10.33383/2018-112*

ANALYSIS OF CHARACTERISTICS OF LED LAMPS WITH *T8* BULB BY VARIOUS MANUFACTURERS

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ABSTRACT

The article analyses the operational characteristics of 10W LED lamps with *T8* bulb manufactured by *ASD* (Russia), *Smartbuy* (Taiwan), and *VOLPE* (PRC) and 18W FL with *T8* bulb manufactured by *PHILIPS* (Poland) including the dependence of these lamps on the supply voltage. The results of measurements show that: a) the period of stabilisation of electric parameters and luminous flux of LED lamps does not cause discomfort of illumination unlike the said FL, the luminous flux of which at the moment of switching on is 70 % of the nominal value, which is reached after 13 minutes; b) with nominal voltage of supply network, the value of luminous flux of *10W ASD LED-T8R-STD* LED lamp (Russia) is 6 % less than the declared one, and that of *Smartbuy SBL-T8–10–64K-A* (Taiwan) and *VOLPE LED-T8–10W/DW/G13/FR/FIX/N* (PRC) is even less; c) the general colour rendering index of all studied LED lamps is less than the declared one (72 instead of 80); d) the flicker index of all studied LED lamps does not exceed the declared value of 5 %; e) the characteristics of LED lamps almost do not depend on changes of the supply voltage within the range of ±10 %.

The recommendations regarding the application of the studied LED lamps are given.

Keywords: LED lamp, *T8* bulb, luminous flux, colour temperature, colour rendering index, luminous flux stabilisation, nominal voltage, luminous efficacy, flicker index

1. PROBLEMS OF INTRODUCTION OF LED-BASED LIGHTING DEVICES IN NATIONAL ECONOMY

The LED-based lighting devices have been increasingly introduced in different areas of life attracting the attention of scientists [1–3]. The apparent advantages of LEDs and LED lamps (efficiency, small size, environmental friendliness) are positively perceived by consumers of different branches of economy. However, experience has shown that, in the early 2010s, manufacturers attributed the high characteristics of LEDs obtained in the laboratory environment to their industrial samples reaching consumers in the form of LEDs and LED-based light sources with declared high characteristics. For instance, the values of the luminous flux of four types of LEDs of the *XLamp XP-E/XP-G/XM–L* series by *Cree* measured by the L.I.S.T. laboratory in 2011 were averagely almost 10 % lower than the declared ones [4].

Studying the efficiency of agricultural application of lighting and irradiating devices based on LEDs and LED lamps, we found that the samples of these devices manufactured for experiments did not always provide required values of luminous flux calculated according to the LED characteristics declared by manufacturers.

In general, our studies of agricultural plants and animals showed an increase of their productive indicators with illumination and irradiation by means of LEDs and LED lamps [5–8], which confirms good perspectives of widening of their application if

a) *b)* *c)*

Fig. 1. Exterior of LED lamps with *T8* bulb: a) *ASD LED-T8R-STD*10Вт 230В *G13*6500K 800lm 600mm (Russia); b) *Smartbuy SBL-T8–10–64K-A* (Taiwan); c) *VOLPE LED-T8–10W/DW/G13/FR/FIX/N* (PRC)

there is reliable information on parameters of such sources.

The articles [1–3] underline the problems related to lighting conditions affecting the visual performance indicators, and the article [9] shows non-compliance of the declared light parameters of LED-based luminaires with actual ones.

Concerning, the goal of the article is the analysis of the practical issue of compliance of the LED lamp parameters declared by manufacturers with the actual ones, which may be of interest to designers of illumination or irradiation and energy departments of consumer enterprises.

2. RESEARCH OF CHARACTERISTICS OF LED LAMPS WITH *T8* BULB

For experimental comparative studies, three LED lamps with *T8* bulb (*ASD LED-T8R-STD10W 230V G13 6500K 800lm 600mm* (Russia), *Smartbuy SBL-T8–10–64K-A* (Taiwan), and *VOLPE LED-T8–10W/DW/G13/FR/FIX/N* (PRC)) and one *PHILIPS TL-D18W/33–640* FL with *T8* bulb manufactured in Poland [10–13] (Fig. 1) were purchased in retail shops of Saransk.

The studies were conducted in the laboratory of the Centre of collective usage "Light Engineering Metrology" (in the Institute of Electronics and Light Engineering of N.P. Ogarev MSU). The electrical and light parameters were measured in normal conditions in accordance with the methodology of GOST [14]. The parameters of all said LED lamps were measured by means of photo colorimeter, *DPS1060* AC power unit, goniophotometer, TKA-PKM (08) flicker/illuminance meter, and TKA-VD/02 spectral colourimeter.

For determination of chromaticity coordinates, the spectral radiometry method was used. For evaluation of colour rendering, the multispectral method was used. In addition, the methods of measurement of correlated colour temperature T_{cc} and dominant wavelength according to GOST [14] were used.

The measurements of power and luminous flux changes of the lamps during the stabilisation period of electrical and light engineering characteristics at nominal U_n were performed using a *Gooch & Housego* photo colorimeter containing an *OL IS7600* Ulbricht sphere with the diameter of 2 m, multi-channel *OL 770 VIS/NIR* spectroradiometer, *770–7G-3.0* fibre-optic cable, *OL410–200 PRECISION LAMP SOURCE* precision DC power unit for power supply of auxiliary lamp *AUX LAMP A180*, and rebar for fixing of the lamps and PC.

The limits of acceptable relative error of luminous flux measurement are ± 9 %; the limits of acceptable absolute error of measurement of x and y chromaticity coordinates are ± 0.002; the limits of acceptable absolute error of measurement of T_{cc} are ± 25 K; relative error of the output current unit is ± 0.02 %.

The functional principle of the photo-colorimeter measuring setup (state register number of a measurement instrument is 66263–160) is based on measurement of absolute spectral distribution of radiant flux, its integrating, and determination of the radiant flux received by the photometric plate that is the end of the fibre-optic input linked with the spectrometer and CCD line. All calculations were made automatically. The setup software represents the information on the control computer screen and sets the measurement conditions [15].

First, the stabilisation period of electrical parameters and luminous flux was determined (Fig. 2 and 3)[1].

The results of all measurements were processed using built-in *GQ-Sof* software with the output of the results to PC and on paper.

The measurements were performed in stable electrical mode after 15 min of continuous lighting ac-

[1] The stabilisation period is the period required for reaching of stable heat conditions of operation of a LED lamp according to GOST [16]. The electrical and light parameters of a lamp are stabilised during this period

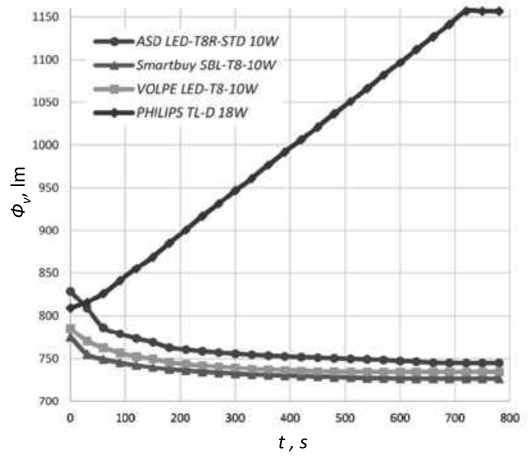

Fig. 2. Changing of luminous flux of the studied lamps Φ_v over the stabilisation period

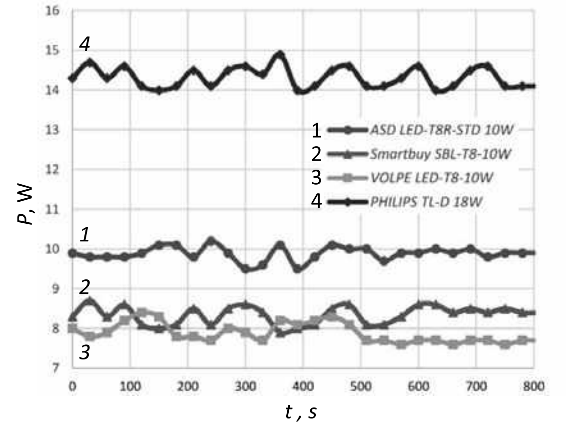

Fig. 3. Changing of power of the studied lamps *P* over the stabilisation period

cording to GOST [14] at an ambient temperature of 25±2 °C, relative humidity of 65±20 %, the atmospheric pressure of 101±4 kPa, U_n of 220±22 V, and current frequency of 50 Hz.

The results of all listed measurements at nominal voltage are presented in Table 1.

In addition, the dependencies of the lighting and electrical parameters of lamps on U_n (Fig. 4–6) were determined.

In accordance with the method of GOST [17], the dependence of the lamp flicker index k_f[2] on U_n with U_n changing within the range of ± 10 % was determined by means of the TKA-PKM (08) flicker/illuminance meter. The k_f measurements were performed during the night time with 45 minutes of luminous flux stabilisation and typical location of all reference points in the premises. In each reference point, the illuminance values were measured three times during 5 minutes period. The relevant results are shown in Figs. 7 and 8.

3. MEASUREMENTS RESULTS ANALYSIS OF CHARACTERISTICS OF LED LAMPS WITH *T8* BULB

The analysis of the results of measurements has shown that the stabilisation periods of electrical parameters and luminous flux of *ASD LED-T8R-STD10W*, *Smartbuy SBL-T8–10W*, and *VOLPE LED-T8–10W* LED lamps and *PHILIPS TL-D18W* FL were equal to 12, 10, 9, and 13 minutes respectively; the corresponding fluctuations of luminous flux of LED lamps were equal to 93 lm (11.2 %), 49 lm (6.3 %), and 51 lm (6.4 %). However, it does not cause discomfort of lighting unlike the *PHILIPS TL-D18W/33–640* FL with its luminous flux at the moment of switching on equal to 70 % (809 lm) of the nominal value, which is reached in 13 minutes.

The analysis of the measurements results of characteristics of lamps at nominal U_n allows us to conclude:

- The values of the luminous flux of all studied lamps are lower than the declared values: *ASD LED-T8R-STD10W*: 46 lm (5.7 %), *Smartbuy SBL-T8–10W*: 376 lm (34.1 %), *VOLPE LED-T8–10W*: 171 lm (18.9 %), and *PHILIPS TL-D18W*: 44 lm (3.6 %);
- The measured T_{cc} of *ASD LED-T8R-STD10W* LED lamp and *PHILIPS TL-D18W* FL are almost equal to the declared values, whereas those of

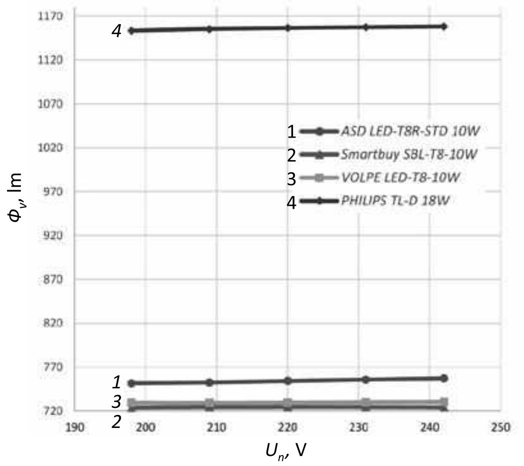

Fig. 4. Dependence of luminous flux of the studied lamps Φ_v on U_n

[2] k_f is the evaluation criterion of relative amplitude of illuminance fluctuation in a lighting installation as a result of time change of luminous flux of light sources with supply of alternating current [18]

Table 1. The Results of Measurements of Electrical and Light Engineering Characteristics of Lamp Samples with Nominal Supply Voltage

Lamp type		*ASD LED-T8R-STD10W*		*Smartbuy SBL-T8–10W*		*VOLPE LED-T8–10W*		*PHILIPS TL-D18W*	
Values		declared	measured	declared	measured	declared	measured	declared	measured
Luminous flux, lm		800	754.3	1100	724.3	900	729.5	1200	1156.6
T_{cc}, K		6500	6491	6400	6260	6500	6362	4000	4037
R_a		> 80	72	> 80	72	> 80	72	> 63	61
Colour purity			0.077		0.058		0.058		
Dominant wave-length, nm			493.6		497.2		494.9		
Chromaticity coordinates	*x*	0.313	0.3118	0.313	0.3160	0.313	0.3145	0.380	0.3818
	y	0.337	0.3364	0.337	0.3402	0.337	0.3351	0.380	0.3879
	u		0.1945		0.1960		0.1968		
	v		0.4721		0.4747		0.4718		
Power, W		10	9.5	10	7.9	10	8	18	14.72
Luminous efficacy, lm/W		80	79.4	110	91.6	90	91.1	67	76.7
k_f,%		< 5	0.8	< 5	0.4	< 5	0.6		8

Smartbuy SBL-T8–10W and *VOLPE LED-T8–10W* LED lamps are 140K (2.1 %) different from the declared ones;

- General colour rendering index R_a of all studied LED lamps is lower than the declared one (72 instead of 80) and is a little less than the declared value;
- k_f of all studied LED lamps is lower than the declared 5 % and is equal to (0.4–0.8) %.

The analysis of the measurements results of characteristics dependence of lamps on U_n has shown that:

- The value of luminous flux of *PHILIPS TL-D18W* FL is decreased by 3.3 lm (0.2 %) with U_n decreasing by 10 % and is increased by 1.6 lm (0.1 %) with U_n increasing by 10 %;
- The power of *PHILIPS TL-D18W* FL is decreased by 1.7 W (11.7 %) with U_n decreasing by

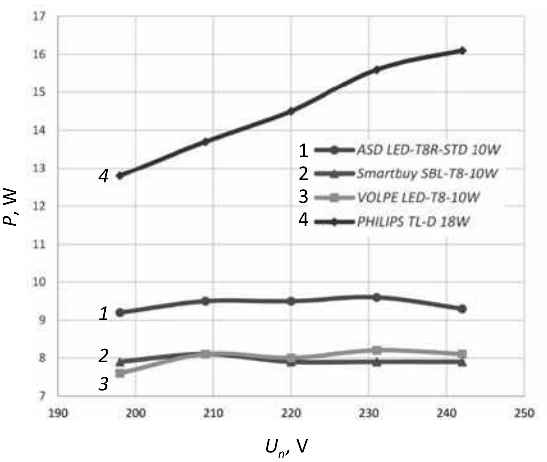

Fig. 5. Dependence of power of the studied lamps P on U_n

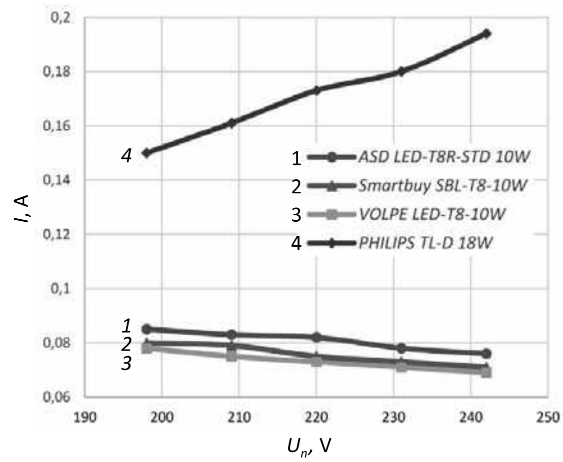

Fig. 6. Dependence of current of the studied lamps I on U_n

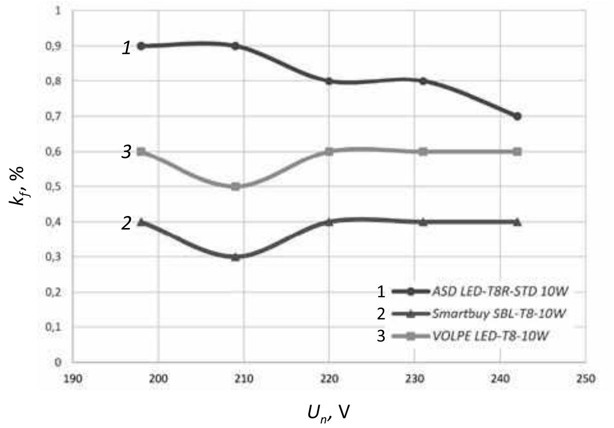

Fig. 7. Dependence of flicker index of the studied lamps k_f on U_n

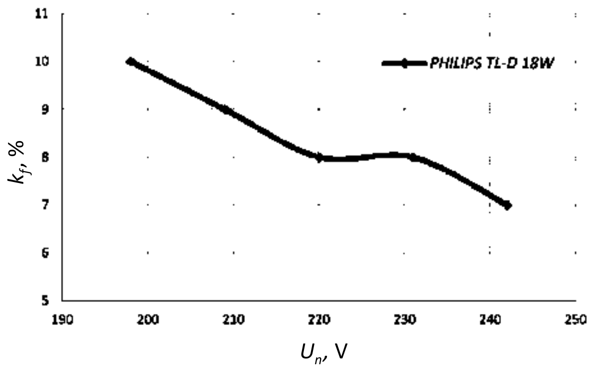

Fig. 8. Dependence of k_f of the *PHILIPS TL-D18W* FL on U_n

10 % and is increased by 1.6 W (11 %) with U_n increasing by 10 %;

- The value of current of *PHILIPS TL-D18W* FL is decreased by 0.023 A (13.2 %) with U_n decreasing by 10 % and is increased by 0.021 A (12.1 %) with U_n increasing by 10 %;
- With U_n changing within the range of ± 10 %, the values of luminous flux, power, and current of all LED lamps are changed within the range of ± 0.4 %.

Therefore, the characteristics of LED lamps nearly do not depend on changes of U_n within the range of ± 10 %.

The analysis of the results of measurements of k_f has shown that:

- With U_n changing within the range of ±10 %, k_f of *Smartbuy SBL-T8–10W* and *VOLPE LED-T8–10W* LED lamps practically does not change equalling 0.4 % and 0.6 % respectively;
- With U_n increasing by 10 %, k_f of *ASD LED-T8R-STD10W* LED lamp practically remains the same, and with U_n decreasing by 10 %, it slightly increases (from 0.8 % to 0.9 %);
- With U_n increasing by 10 %, k_f of *PHILIPS TL-D18W* FL decreases from 8 % to 7 %, and with U_n decreasing by 10 %, it increases from 8 % to 10 %.

Based on the conducted study, the following recommendations may be given:

- According to GOST [18], the *ASD LED-T8R-STD10W* 230*V G13 6500 K 800 lm 600 mm* (Russia), *Smartbuy SBL-T8–10–64K-A* (Taiwan), and *VOLPE LED-T8–10W/DW/G13/FR/FIX/N* (PRC) LED lamps cannot be recommended to be applied in luminaires for lighting of premises of administrative buildings, kindergartens, educational institutions since their R_a appeared to be 10 % less than 80;
- The *Smartbuy SBL-T8–10–64K-A* (Taiwan) and *VOLPE LED-T8–10W/DW/G13/FR/FIX/N* (PRC) LED lamps should undergo pre-installation inspection of luminous flux since its value of both lamps was significantly lower than the declared one.

The main conclusion of the conducted study is that the actual values of the luminous flux of some LED lamps do not comply with the declared values. For instance, the values of the luminous flux of *Smartbuy SBL-T8–10W* and *VOLPE LED-T8–10W* LED lamps appeared to be (20–30) % lower[3].

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