

## COMPARATIVE ANALYSIS OF THE CHARACTERISTICS OF LED FILAMENT LAMPS FOR HOUSEHOLD LIGHTING

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### ABSTRACT

This paper examines the characteristics of LED filament lamps from various manufacturers: LLC “Lisma” (Russia), an American company with production in China “GENERAL LIGHTING CO. LTD”, a joint Chinese-Russian company “Uniel” and Taiwan company “Smartbuy” in the A60 bulb – the time of stabilization of characteristics, luminous flux, colour temperature, colour rendering index, flicker index, radiation spectrum during 6000 hours of burning. The research was carried out on the Gooch&Housego measuring system. The results of experimental studies that showed that the clear leader in the test results is the lamp SDF-8 (LISMA), according to GOST of all tested samples of led filament lamps, it can be recommended for lighting in lighting devices for household lighting.

**Keywords:** luminous flux, luminous efficacy, colour temperature, colour rendering index, radiation spectrum, luminous intensity distribution curves (LIDCs), lighting, stabilization time, household premises

### 1. INTRODUCTION

LED lamps are considered the most energy-efficient, reliable and promising light sources (LS) nowadays. There is a wide range of these LSs on the market, including filament LED lamps (FLED), which allow these products to select rationally with consideration of their purpose and major character-

istics [1–6]. The purpose of this work is to compare light and engineering characteristics of FLED lamps for household applications in order to increase rationality of selection of these LSs primarily for replacement of incandescent lamps.

### 2. THE STUDY OF CHARACTERISTICS OF FLED LAMPS WITH A60 BULBS

For the comparative study, FLED lamps manufactured by Lisma LLC (Russia), the American company with PRC-based production facilities *General Lighting Co., Ltd*, the joint Chinese and Russian company *Uniel* and the Taiwan company *Smartbuy* were selected. The power of the studied lamps was equal to 5,8 W and 10 W, the bulb type was A60, the cap type was E27.

The studies were conducted in the Light Engineering Metrology laboratory (Electronics and Light Engineering Institute of the N.P. Ogarev Mordovia State University) using the measurement system by *Gooch & Housego* consisting of the *OL IS7600* photometer sphere with diameter of about 2 m, the *OL 770 VIS/NIR* spectroradiometer, the *OL410–200 PRECISION LAMP SOURCE* DC supply unit (for supply of an auxiliary lamp), fasteners for lamps and a PC [7].

Stabilisation time of the compared characteristics of the FLED lamps was defined. For *GLDEN-A60S-10–230-E27–2700* (*General Lighting Co., Ltd*) and SDF-8 (LISMA) it was equal to 5 min, for *SKY-A60–8–30K-E27* lamps (*Uniel*) it was equal

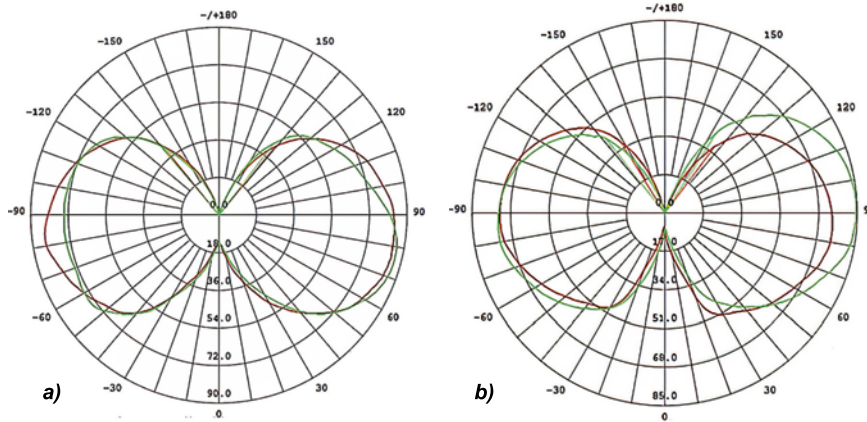


Fig. 1. LIDCs of the lamps:  
 a: SDF-A60-8-27K-E27 (Lisma); b: GLDEN-A60S-10-230-E27-2700 (General Lighting)

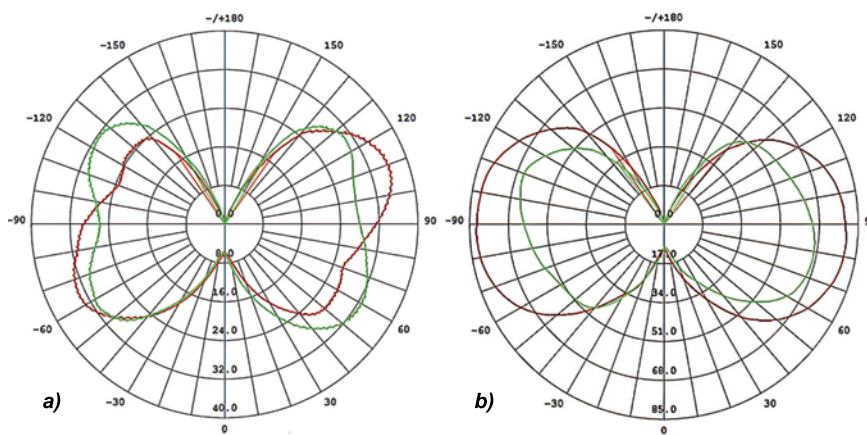


Fig. 2. LIDCs of the lamps:  
 a: SBL-A60F-5-30K-E27 (Smartbuy); b: SKY-A60-8-30K-E27 (Uniel)

to 7 min, and for *SBL-A60F-5-30K-E27 (Smartbuy)* it was equal to 4 min.

Lamp parameters were measured by means of the photometer sphere in accordance with standards [8, 9]. Light flickering level was measured by means of a TKA-PKM 08 illuminance and flicker meter that measures flicker index  $k_f$  in the (380–760) nm spectral region.

Table 1 summarises the results of measurements of characteristics of the studied lamp samples and the values of the characteristics declared by manufacturers.

The analysis of the results showed that the measured values of luminous flux  $\Phi_v$  for lamps manufactured by Lisma LLC (780 lm) and *General Lighting Co., Ltd* (890 lm) correspond to the declared values (770 lm and 870 lm respectively) and are significantly lower (655 lm and 355 lm) than the declared values (800 lm and 480 lm respectively) in lamps manufactured by *Uniel* and *Smartbuy*. The measured values of correlated colour temperature  $T_{cp}$  and general colour rendering index  $R_a$  of all lamps correspond to the declared ones. Only power of the lamp by LISMA was approximately equal

to the declared value while it was less than the declared value for the other lamps by 30 %. Actual power value of the lamp *GLDEN-10 (General Lighting Co., Ltd)* which is less by 30 % does not affect the level of  $\Phi_v$ ; it corresponds to the declared one; reduction of power by 32.5 % in lamps by *Smartbuy* led to reduction of  $\Phi_v$  by 18.1 % and reduction of power by 35.6 % for lamps by *Uniel* led to reduction of  $\Phi_v$  by 26 %. Luminous efficacy  $\eta_v$  of all studied lamps turned out to exceed the declared values.  $k_f$  of the lamps by LISMA LLC and by *General Lighting Co., Ltd* turned out to be much less than the declared values (0.2 %); it was within the specification limits in the lamp *SKY-8 (Uniel)* and equalled at least 35 % in the lamp *SBL-5 (Smartbuy)*.

Radiation spectra of the lamps were studied by means of the *OL 770VIS/NIR* spectroradiometer. Radiation spectra of FLED lamps are continuous, it occupies the entire visible region and its peak wavelength lies within the yellow-orange part of the spectrum providing warm white light of the lamps. Based on CIE (Commission International d’Eclairage) 1931 standard colorimetric sys-

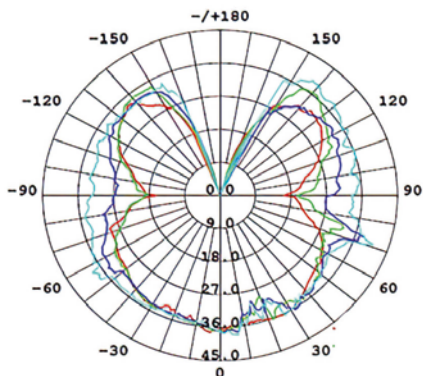


Fig. 3. LIDCs of the B230-40 incandescent lamp (with A60 bulb)

tem, chromaticity coordinates of the lamp SDF-8 (LISMA) are (0.4558, 0.4104), which corresponds to  $T_{cp}$  of 2,700 K; the chromaticity coordinates of the lamp SKY-A60-8-30K-E27 (Uniel) are equal to (0.4338, 0.4009), which corresponds to  $T_{cp}$  of 3,000 K.

Using the goniophotometer set GO 2000A (Everfine), LDCs of the studied lamps were registered (Figs. 1 and 2). The figures show that the shapes of LIDCs are primarily sine [10]; maximum luminous intensity of SDF-A60-8-27K-E27 is equal to 87 cd, maximum luminous intensity of SBL-A60F-5-30K-E27 is equal to 35 cd, maximum luminous intensity of GLDEN-A60S-10-230-E27-2700 is 84 cd and that of the lamp SKY-A60-8-30K-E27 is 83 cd. As a comparison, Fig. 3 shows LIDC of a B230-40 incandescent lamp (with A60 bulb) [11]. As we can see, LIDCs of FLED lamps are merely different from LIDC of an incandescent lamp.

Table 2 summarises the results of measurements of the characteristics of FLED lamps after 1,000, 2,000, 3,000, 4,000 and 6,000 hours of continuous work and the results of calculation of the luminous flux retention factor of the lamps after  $n$  hours of work ( $L$ ) using the formula from standard [8]:

$$L = (\Phi_{v,n} / \Phi_{v,o}) \cdot 100, \%$$

where  $\Phi_{v,o}$  is the initial  $\Phi_v$ ,  $\Phi_{v,n}$  is the  $\Phi_v$  after  $n$  hours of work. The lamp GLDEN-A60S-10-230-E27-2700 (General Lighting Co., Ltd) was out of service after 3,466 hours of work.

Fig. 4 shows the graphs of changes in  $\Phi_v$  of the lamps in the course of continuous work.

Standard [8] sets 5 categories based on  $L$ : A, B, C, D and E and each of them is characterised by reduction of nominal  $\Phi_v$  by 10 % as compared to a previous category, with  $\Phi_{v,o}$  at 0 hours.

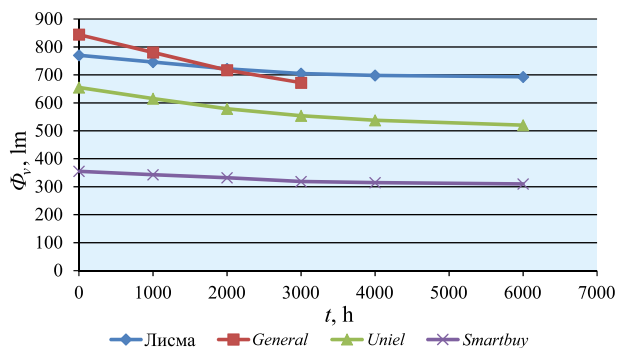


Fig. 4. Reduction dynamics of luminous flux of the compared lamps

Based on the results of the tests, after 6000 hours of operation, the lamp SDF-8 (LISMA) may be categorised as A-category, the lamp SKY-A60-8-30K-E27 (Uniel) may be categorised as B-category, and the lamp SBL-A60F-5-30K-E27 (Smartbuy) may be also categorised as A-category, however, its  $k_f$  is too high.

### 3. ANALYSIS OF THE RESULTS OF LAMP CHARACTERISTICS COMPARISON

As a result of the studies of the lamps conducted in the course of 6,000 h of continuous operation, the following conclusions may be drawn:

- SDF-8 lamp (Lisma) has the highest  $L$  (90 %) and the least  $k_f$ ;
- SBL-A60F-5-30K-E27 lamp (Smartbuy) has  $L = 87.3 \%$  and the highest  $k_f$  which exceeds the acceptable value by 7 times and more;
- $L$  of SKY-A60-8-30K-E27 lamp (Uniel) is equal to 79.4 % and  $k_f$  does not exceed the standardised value;
- $T_{cp}$  of all lamps virtually did not change (with consideration of acceptable errors).

As noted above, the lamp GLDEN-A60S-10-230-E27-2700 (General Lighting Co., Ltd) was broken after 3466 hours of operation, its  $L$  was equal to 79.6 % after 3000 hours of operation and  $k_f$  did not exceed the standardised value. As a result, this FLED lamp cannot be recommended for lighting of living premises due to low service life and  $L$ . According to standard [8], it may be categorised as C.

SDF-8 (LISMA) is the only lamp which may be categorised as A as per standard [8] and it may be recommended for application in household lighting devices.

Table 1. Parameters of the Lamp Samples

Lamp type	SDF-8 (Lisma)		GLDEN-A60S-10- 230-E27-2700 (General Lighting)		SKY-A60-8-30K-E27 (Uniel)		SBL-A60F-5-30K-E27 (Smartbuy)	
	declared values	measured values	declared values	measured values	declared values	measured values	declared values	measured values
$\Phi_v$ , lm	780	770	890	870	800	655	480	355
$T_{cp}$ , K	2,700	2,736	2,700	2,717	3,000	2,991	3,000	2,946
$R_a$	> 80	85	> 80	85	> 80	83	> 80	81
Power, W	8.0	7.6	10.0	7.0	8.0	5.4	5.0	3.22
$\eta_v$ , lm/W	97.5	101.3	89.0	124.2	100.0	121.0	96.0	110.0
$k_f$ , %	< 1	0.2	< 5	0.2	< 5	3.5	< 5	35

Table 2. Time Behaviour of Lamp Parameters

Lamp type	Parameters	Operation duration, h					
		0.25	1,000	2,000	3,000	4,000	6,000
SDF-8 (Lisma)	$\Phi_v$ , lm	770	746	722	705	700	693
	$k_f$ , %	5	0.5	0.5	2	0	0.5
	$L$ , %		96.9	93.8	91.6	90.9	90.0
GLDEN-A60S-10- 230-E27-2700 (General Lighting)	$\Phi_v$ , lm	844	771	702	672		
	$k_f$ , %	5	0.2	2	3.5		
	$L$ , %		91.4	83.2	79.6		
SKY-A60-8-30K-E27 (Uniel)	$\Phi_v$ , lm	655	605	579	554	529	520
	$k_f$ , %	5	3.5	3.5	0.5	0	
	$L$ , %		92.4	88.4	84.6	80.8	79.4
SBL-A60F-5-30K-E27 (Smartbuy)	$\Phi_v$ , lm	355	343	332	319	315	310
	$k_f$ , %	5	35	35	30	25.5	26
	$L$ , %		96.6	93.5	89.9	88.7	87.3

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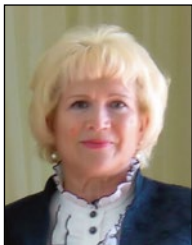
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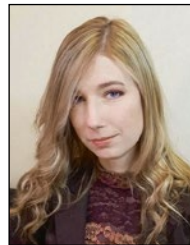
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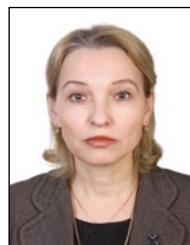
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