MEASUREMENT OF ELECTRIC, PHOTOMETRIC AND COLORIMETRIC PARAMETERS OF LED USING IN DIFFERENT AMBIENT TEMPERATURES

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ABSTRACT

In the paper present the test results of measurements and calculations of electric, photometric and colorimetric parameters LEDs of different construction. The parameters have been measuring in different ambient temperatures of LEDs. The ambient temperature has been changing from 25^{0}C to -25^{0}C in step of 5^{0}C. All tested LEDs supply by line voltage 230 V and equipped in bases E27, E14 and GU10. Registered changes in function of ambient temperature following parameters : current, power, power factor, relatively changes of luminous flux, spectral distribution. On base spectral distribution calculated color temperature (T_c) and color rendering index (*CRI*). In the paper presents chosen result of measurements and calculations.

Keywords: Electric sources, LED, ambient temperature, luminous flux, color temperature, color rendering index, power, power factor.

1. INTRODUCTION

The construction of light emitting diodes (LED) are growing very fast. Applications this new sources is extending in very wide range of lighting area, in outdoor and indoor lighting. The LEDs are used in different conditions, ambient temperature has influence of main electric, photometric and calorimetric parameters. The knowledge of influence ambient temperature for main parameters is important. The wide range of use LED retrofit lamps in lighting is reason to check the influence of ambient temperature for main electric and photometric parameters . The chosen types LED retrofit lamps to test are in current offer in the market. In the paper show many chosen test results of measures and calculations of electric and photometric parameters of chosen LED lamps from all done.

2. SUBJECT AND SCOPE OF STUDY

Chosen LED retrofit lamps to test are typical in the market, supply by line voltage (230 V) equipped with typical bases E27, E14 and GU10. The main electric and photometric parameters chosen LED lamps show in the table1.

Table 1 – General technical information of tested LED

No.	*U* [V]	*I* [mA]	*P* [W]	Base	Color	*CRI* [-]	*Φ* [lm]	Timelife [h]	Beam angle [^{0}]
1.	230	45	2.0	E27	x	x	x	x	x
2.	230	x	1.5	GU10	cool white	x	100	20 000	150^0
3.	230	x	1.5	GU10	warm white	x			
4.	230	x	1.5	GU10	warm white	x	65	20 000	60^0
5.	220-240	31	1.8	GU10	3 000 K	> 70	150	25 000	120^0
6.	220-240	31	1.8	GU10	6 400 K	> 70	150	25 000	120^0

No.	*U* [V]	*I* [mA]	*P* [W]	Base	Color	*CRI* [-]	*Φ* [lm]	Timelife [h]	Beam angle [^{0}]
7.	230	x	1.5	GU10	cool white	x	110	20 000	150^0
8.	230	x	5.0	GU10	warm, 827	≥ 80	350	30 000	120^0
9.	220-240	x	x	E14	x	x	x	x	x
10.	230	x	9.0	E27	3 000 K	x	x	x	x
11.	220-240	x	12	E27	2 700 K	90	810	25 000	x
12.	85-265	x	3	E27	warm white	x	210	20 000	120^0
13.	230	x	0.67	E14	red	-	x	25 000	12^0
14.	220-240	x	1	E14	blue	-	x	25 000	12^0
15.	230	x	0.82	E14	green	-	x	25 000	12^0
x – the information is not available									

3. RESEARCH MEASURING SYSTEM AND MEASUREMENT METHOD

Registration of electrical and photometric parameters as well as registration of spectral distribution curves of semi-conductor light sources were conducted by means of thermal test chamber, in which tested light sources were placed. Schematic diagram of the measuring system is presented in fig. 1.

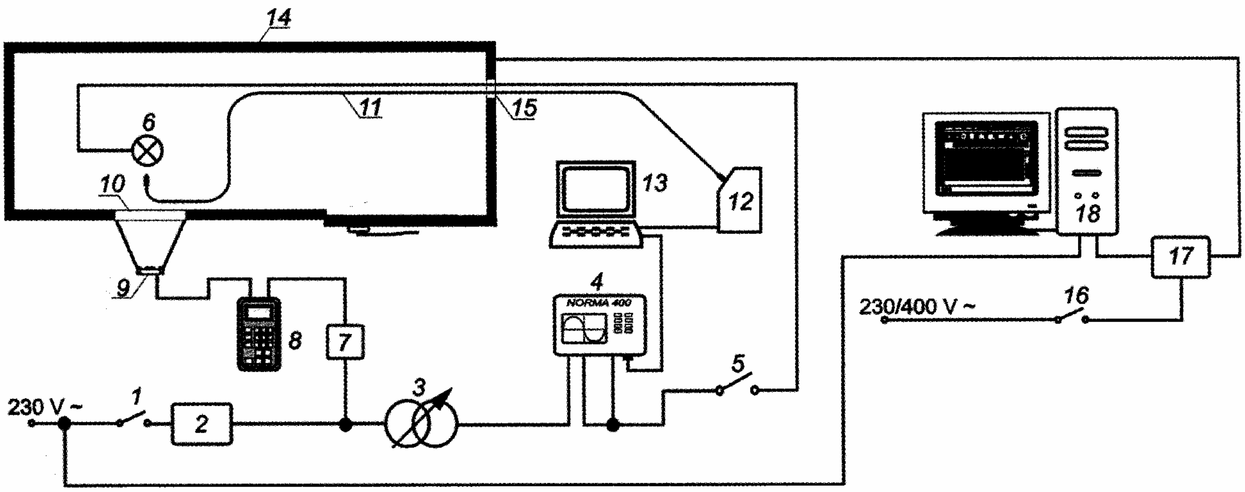

Figure 1 – Schematic diagram of the measuring system

1, 5, 16 – power switches, *2* – voltage stabilizer, 3 – autotransformer, *4* – power analyzer, *6* – tested light source, *7* – external power supply integrated with illumination meter, *10* – circular glass enabling observation, *11* – opitical fibre, *12* – spectrometer, *13* – PC registering spectral distribution, *14* – environmental test chamber made of sandwich panels, *15* – culvert, *17* – chamber control unit, *18* – PC controlling the chamber

Light sources *(6)*, by means of power switches *(1, 5),* were fed on voltage stabilizer *(2)* which provided constant rms voltage with an accuracy of 0.1%. By means of the autotransformer *(3)* the value of 230 V was set. Individual electrical parameters are registered by the power analyzer *(4)* integrated with a PC *(13)*. Photometric parameters are controlled by a photometer head *(9)* connected to the control unit of illumination meter *(8)*, which is fed on the external power supply *(7)*. Photoelectric cell was permanently fixed to the apex of the cone, which was mounted to the external side of the circular glass *(10)* (the one from the thermal chamber). It measures luminous intensity in a selected direction. If one assumes that shapes of photometric forms of the light sources under tests are constant (not dependent on the ambient temperature), then the measurement values registered by the illumination meter represent relative changes of luminous flux. The meters (power analyzer and illumination meter) were connected to the PC with the use of RS-232C serial communication cable. Optical fibre *(11)* introduced to the inside of the thermal chamber *(14)* through the culvert *(15)* provides measurement signal (light) to the spectrometer *(12)* which is placed outside. Communication between the spectrometer and the PC takes place by means of USB 2.0 interface. Registration of individual parameters of the researched LED sources was undertaken after 20 minutes of their operation. During measurements all the light sources were placed vertically (their longitudinal axis was perpendicular to the circular glass). The process of temperature regulation inside the research area was controlled by the PC *(18)* and operated by a PLC driver *(17)*. Measurements started at 25^0C which was taken as a reference temperature.

4. THE RESULTS OF MEASUREMENTS AND CALCULATIONS

4.1. Relatively changes of electric and photometric parameters in function of ambient temperature

During tests measured influence of ambient temperature for general electric and photometric parameters, like power, current, power factor and luminous flux. In the figures 1, 2 and 3 show the influence of the ambient temperature of LED for chosen measured parameters. Figure 2a - power, figure 2b - power factor and figure 3c - luminous flux in the relatively values. The ambient temperature has been changing from -25 °C to 25 °C. The results concerning of 15 LEDs.

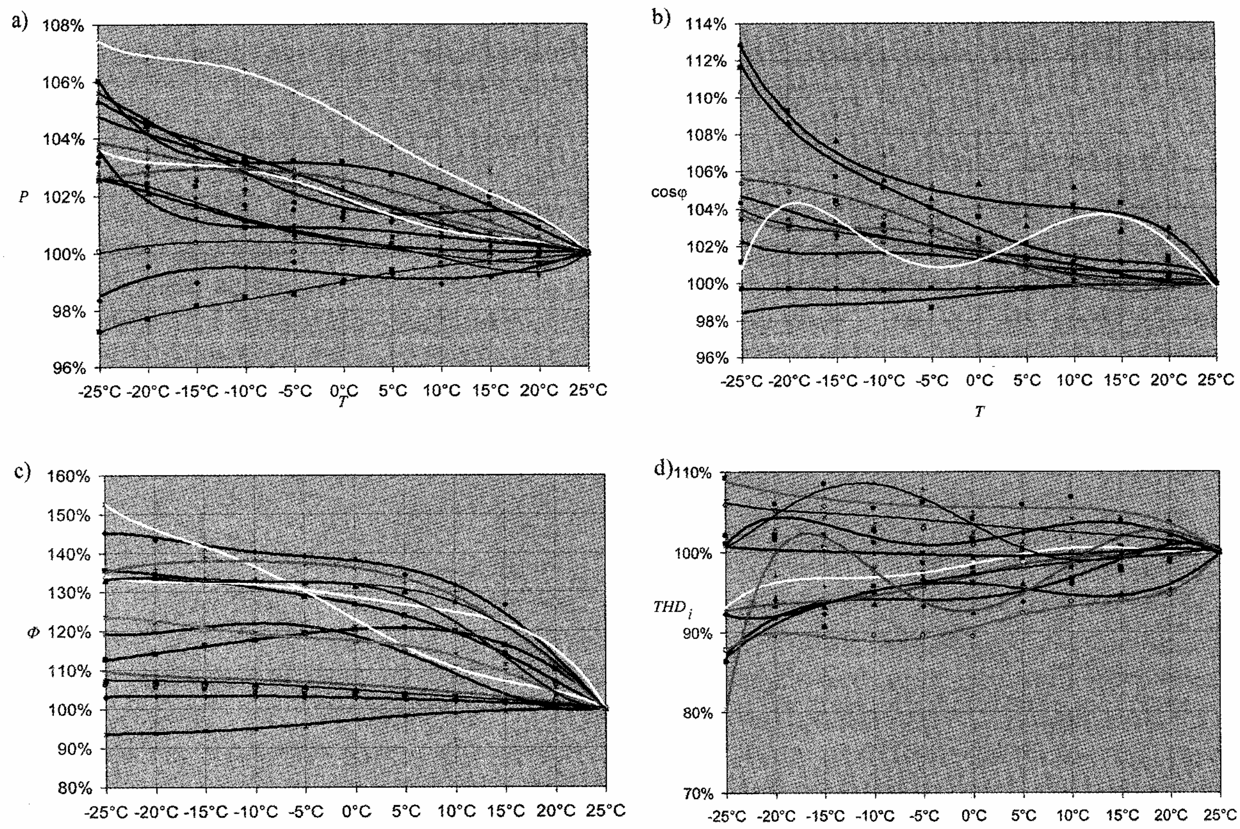

Figure 2 The a) power, b) power factor, c) luminous flux, d) relatively changes of *THD_i* in function of ambient temperature

The changes of THD_i and current time characteristics in function ambient temperature were tested. The relatively changes of THD_i in function ambient temperature are show in the figure 2d. The ambient temperature has been changing from -25 °C to 25 °C. The results concerning of 15 LEDs.

4.2. Changes of spectral distribution

The ambient temperature of LED are not critical influence for the spectral distribution shape. The change concern the value of power distribution it is consequence of temperature influence for LED power. There are two spectral characteristics (for LED nb 2 and 3) in the figure 8. There are two characteristics measured in three ambient temperatures 25 °C, 0 °C and − 25 °C in the figure 3.

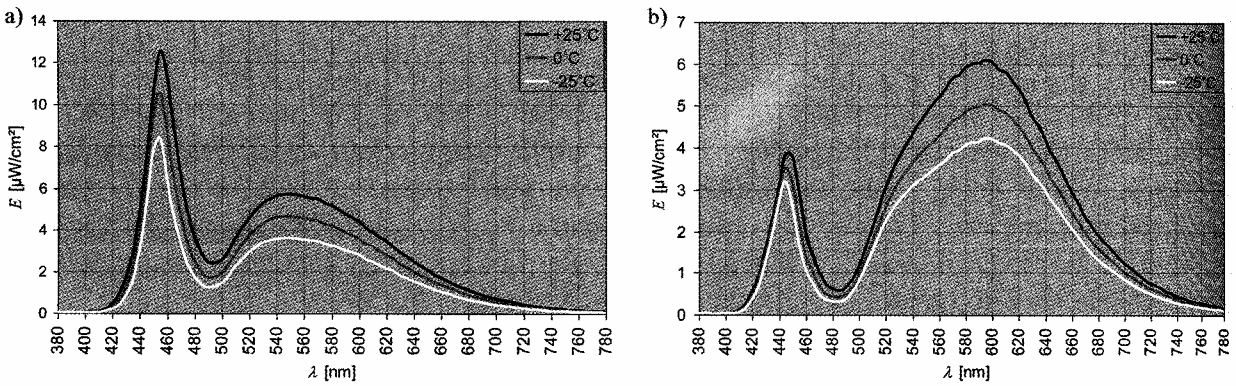

Figure 3 The changes of spectral distribution in function of ambient temperature for two LEDs, nb a) 2 and b) 3

4.3. Changes of T_c and *CRI*

The changes of color temperature and color rendering index for three LEDs are showed in the picture 4. There are samples of changes T_c and *CRI* in function ambient temperature in picture 9, for three chosen types of LEDs. The ambient temperature has been changing from -25 °C to 25 °C. The results concerning of chosen three LEDs, nb. 1, 2 and 3, data showed in table 1.

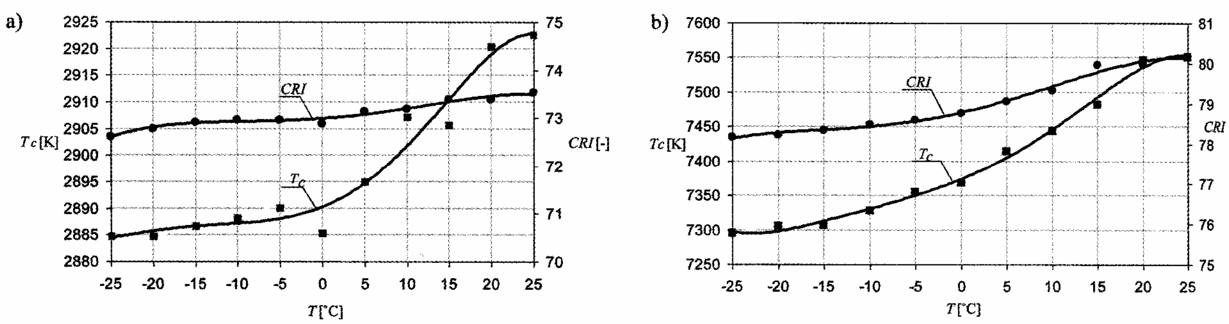

Figure 4 Changes of T_c and *CRI* in function of ambient temperature for temperature for two LEDs, nb a) 1 and b) 2

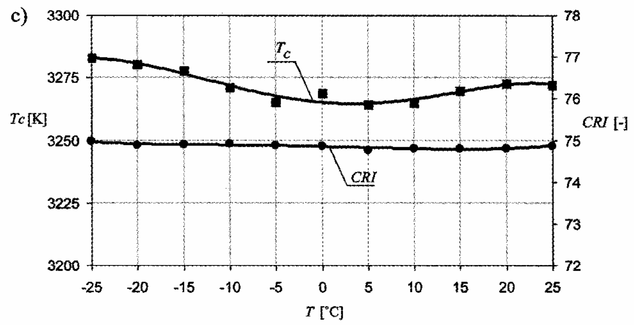

Figure 5 Changes of T_c and *CRI* in function of ambient temperature LED nb 3

4.4. Changes of chosen parameters of LEDs in function of ambient temperature.

The changes of power consumption P, total harmonic distortion *THD, color rendering index CRI*, and color temperature T_c in function of ambient temperature showed in table 2.

Table 2 – The changes of chosen parameters of LEDs in function ambient temperature

No.	P [W]		ΔP [%]	THD_i [%]		ΔTHD_i [%]	*CRI* [-]		ΔCRI [%]	T_c [K]		ΔT_c [%]
	25°C	-25°C		25°C	-25°C		25°C	-25°C		25°C	-25°C	
1.	1.95	2.01	3.1	25.1	23.1	-8.0	73.5	72,6	-1.2	2923	2885	-1.3
2.	2.29	2.43	6.1	205.7	177.5	-13.7	80.1	78.2	-2.4	7550	7292	-3.4
3.	2.45	2.51	2.4	196.1	181.3	-7.5	74.9	75.0	0.1	3272	3283	0.3
4.	1.62	1.69	4.3	25.7	22.6	-12.2	64.4	64.0	-0.6	3330	3281	-1.5
5.	1.98	2.04	3.0	32.1	32.8	2.1	70.8	71.3	0.7	3092	3110	0.6
6.	1.82	1.88	3.3	32.1	32.8	2.1	71.8	69.5	**-3.2**	6828	6635	2.5
7.	3.19	3.43	7.5	142.3	132.0	-7.2	82.2	82.7	0.6	3027	3064	1.2
8.	3.36	3.54	5.7	32.8	34.9	6.4	73.1	73.2	0.1	2765	2776	0.4
9.	5.31	5.32	0.2	55.3	58.6	6.0	66.4	66.1	-0.5	3260	3178	-2.5
10.	8.43	8.29	-1.7	67.0	67.7	1.1	66.5	66.7	0.3	3087	3025	-2.0
11.	13.72	13.34	-2.8	29.4	29.7	1.0	66.5	66.7	0.3	3077	3025	-1.8
12.	2.86	2.93	2.4	217.7	188.4	-13.4	61.3	61.2	-0.1	3106	3022	**-2.7**
13.	0.86	0.91	**5.8**	23.4	23.6	1.0	x	x	x	x	x	x
14.	0.74	0.76	2.7	29.4	23.6	**-19.6**	x	x	x	x	x	x
15.	0.55	0.56	1.8	26.3	28.7	9.2	x	x	x	x	x	x
x - not applicable, numbers in bold – the greatest changes												

5. SUMMARISE

On the basis of laborator y measurements main electric, photometric and colorimetric parameters for chosen samples of LED retrofit lamps in function of ambient temperature you can draw following conclusions. At constant supply voltage electrical, photometric and colorimetric parameters of LEDs are the function of temperature. The presented data show that the luminous flux is the most dependent parameter (from all measured) on the ambient temperature. The relative changes of luminous flux value reach 50% at ambient temperature in range 25°C do – 25°C. For all of tested LEDs (excluding the nb 14) the value of luminous flux is increasing when the ambient temperature is decreasing. For most of the testing sources is observing increasing of power, power factor and increasing the total harmonic distortion. The changes of power and power factor are the preferred from quality of electricity viewpoint. The not sensitive parameters of the ambient temperature changes are T_c and *CRI*, the relative changes of this parameters are less than 5% in temperature range 25°C do – 25°C.

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