ITM Web of Conferences **19**, 01042 (2018) https://doi.org/10.1051/itmconf/20181901042
ZKwE'2018

Forecasting long term lumen maintenance of LED lamps

Malgorzata Zalesinska[1,*], *Julita* Zablocka[1], *Krzysztof* Wandachowicz[1], and *Agata* Raczak[1]

[1] Poznan University of Technology, Institute of Electrical Engineering and Electronics, 5 M. Sklodowska-Curie Square, Poznan, Poland

Abstract. Due to the very high life of LED lamps, amounting to tens of thousands of hours, the life declared by the manufacturer is most often life determined on the basis of the method of forecasting the long term lumen maintenance. Life forecasting is based on operational measurements of the luminous flux drop over a period of at least up to 6000 h every 1000 h and extrapolation of the obtained results with an appropriate exponential curve. The article presents the results of measurements of luminous flux changes in the range of 0 to 9000 h of operation of light sources. The analysis of the obtained results was carried out and the life of the tested lamps was estimated.

1 Introduction

The control of LED lamp parameters in accordance with the regulations [1] is usually only limited to the initial parameters [2-4]. Measurements of the luminous flux maintenance are rarely carried out for 6000 h of lamp lighting [5], not to mention the luminous flux drop for longer times and checking the declared life on this basis.

The life L_x of a single LED lamp is determined by the time at which the light source provides at least the declared percentage of the initial luminous flux [6]. Measurements of the operational drop in the luminous flux of LED are time-consuming measurements, which is why a method for forecasting the long term lumen maintenance and estimating the life of LED [8] on this basis was developed. The luminous flux drop ($\Phi'(t)$) during operation is described in the publication [7] with an exponential curve:

$$\Phi'(t) = B \cdot exp(-\alpha t) \qquad (1)$$

where:
t - operating time, B – projected initial constant, α – decay rate constant.

In order to determine the lumen maintenance life, the measurements should be carried out at least for the first 6000 h of lighting, every 1000 h. If the measurements are carried out for longer operating times (every 1000 h), all measurement results between the half and the end of the time considered should be taken into account in order to assess the life [7].

The method of LED lamp lumen maintenance life forecasting described in the publication [7] allows to calculate the life (L_p) for the assumed luminous flux drop percentage (p) based on the dependence (2):

$$L_p = \frac{\ln\left(100 \cdot \frac{B}{p}\right)}{\alpha} \qquad (2)$$

* Corresponding author: malgorzata.zalesinska@put.poznan.pl

2 Description of test objects

In order to assess the actual luminous flux drop during the 9000 h lamp lighting and estimate the long term lumen maintenance in accordance with the procedure described in [7].

Six lamps from different manufacturers were selected for the tests. The basic information available on the packaging of the product as well as the results of measurements of the initial parameters of the tested LED lamps are described in the publication [8]. The appearance of the tested lamps is shown in Figure 1.

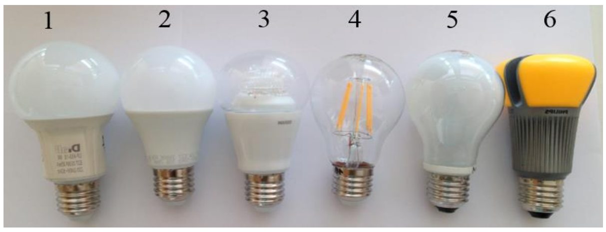

Fig. 1. The appearance of the tested LED lamps.

3 Measurement of luminous flu

The measurement stand and the measurement of the luminous flux are described in detail in [8, 9]. Relative changes in luminous flux of the tested lamps in [%] during the time from 0 to 9000 h of lighting are summarised in Table 1. On the basis of the measured luminous flux drop, the life forecast up to 70%, 80% and 90% of the initial value of the luminous flux was calculated for 6000 h of lighting. The results of calculations L_p are presented in table 2. Figure 2 shows the course of forecast curves of luminous flux drop up to 25,000 hours of lighting together with the actual measurement results.

Table 1. Relative changes in the luminous flux of the lamps.

t [h]	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
0	1,000	1,000	1,000	1,000	1,000	1,000
1000	0,977	0,784	0,951	0,947	0,890	0,994
2000	0,961	0,736	0,931	0,904	0,826	0,983
3000	0,959	0,733	0,945	0,880	0,800	0,996
4000	0,943	0,719	0,918	0,814	0,750	0,981
5000	0,943	0,716	0,917	0,783	0,749	0,981
6000	0,941	0,716	0,917	0,741	0,749	0,979
7000	0,936	-*	-*	0,703	0,745	0,978
8000	0,932	-	-	0,620	0,732	0,978
9000	0,927	-	-	0,422	0,730	0,975

* - the light source burnt out after 6000 h

Table 2. Results of lumen maintenance life.

Lamp	α	B	L_{70} [h]	L_{80} [h]	L_{90} [h]
No. 1	7,465 E-06	0,979	44960	27072	11293
No. 2	1,587 E-05	0,776	6456	-	-
No. 3	7,328 E-06	0,954	42231	24008	7935
No. 4	4,959 E-05	1,001	7220	4527	2151
No. 5	3,487 E-05	0,895	7053	3224	-
No. 6	2,780 E-06	0,995	126583	78556	36194

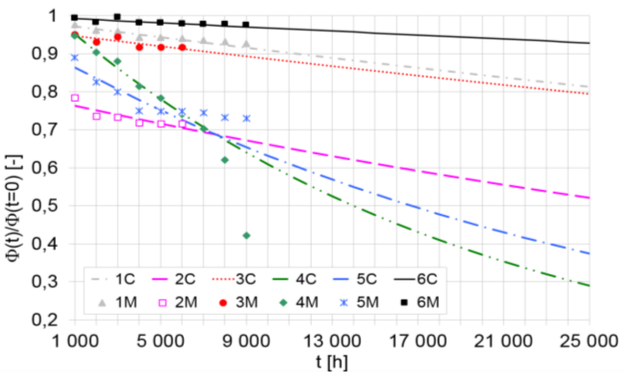

Fig. 2. Measurement results and curves extrapolated for obtained results. "C" from calculation, and "M" from measurements.

The forecast life was determined for all 6 tested lamps, although two LED lamps (no. 2 and no. 3) burnt out after 6000 h. In the case of lamp no. 2, it was impossible to determine the life for the assumed luminous flux drop up to 80% and 90% of initial value, and for lamp no. 5 for 90%. This was caused by a very large drop in the luminous flux at the beginning of operation. The luminous flux of lamp no. 2 during the first thousand hours of lighting dropped by over 21%, and of lamp no. 5 by 11%. In other cases, the forecast life was determined for all three luminous flux drops most frequently used in practice (70%, 80% and 90%).

Based on the measurements and calculations carried out, it was possible to divide the tested lamps into two groups. The first of them includes lamps with a low luminous flux drop during operation (no. 1, 3 and 6), and thus high life. In the case of lamps no. 1 and no. 3, life L70(6k) exceeded 40,000 h, and in the case of lamp no. 6 even 12,000. However, despite such good forecasts, lamp no. 3 burnt out after 6000 h. Due to the relatively low luminous flux drop within 6000 h of lighting, this lamp can be included in the group of good quality lamps. The second group are lamps that had a significant luminous flux drop during the first 6000 h of lighting. In each case, this drop was greater than 20%, and thus the lamps did not meet the requirements of regulation [1] regarding the required value of the luminous flux maintenance coefficient after 6000 h of lighting (≥80%). On the basis of such a large luminous flux drop, the forecast life was much lower than for the other lamps. Nevertheless, based on the example of lamp no. 2, it can be stated that forecasting life based on the first 6000 h of lighting does not always provide a good estimation. On the basis of the measurements for subsequent lighting times, it can be seen that the flux drop is much lower than it would result from the forecast values based on 6000 h (Fig. 2).

4 Summary

The measurements of the operational drop of the luminous flux were carried out only on single copies and it is not possible to generalise them for the whole production. Nevertheless, they confirmed the need to constantly monitor products on the market, and particularly to carry out tests after 6000 h in order to fully assess the quality of LED lamps. As the tests have shown, even though all the lamps met the criterion of the minimum initial value of the luminous flux [8], only half of them had a luminous flux maintenance coefficient higher than the required one [1]. The tests carried out also allowed to calculate the expected life of lamps based on the initial 6000 h of lamp operation and evaluation of the procedure described in the publication [7]. Based on the analysis of the measurement results, it can be concluded that the limit of the measurement time up to 6000 h [7] as a minimum sufficient to estimate the life of lamps may be insufficient in numerous cases. Confirmation of this thesis requires the authors to continue the tests and carry out verifications after at least 10,000 h of operation.

References

1. Commission Regulation (EU) No. 1194/2012
2. Pawlak, M. Zalesińska, Management Systems in Production Engineering **25**, 35-41 (2017)
3. St. Szwedek, M. Zalesińska, M. Górczewska, Pozn. Univ. Technol. Acad. J. Electr. Eng. **92**, 153-164 (2017)
4. T. Tabaka, Light & Engineering **23**, No 1, 79-86 (2015)
5. Zalesińska M, Zabłocka J, Wandachowicz K.: Prz. Elektrotech. **3**, 188-192 (2018)
6. *PN-EN 62612:2013*.
7. *IES TM-21-11*.
8. J. Zabłocka, M. Zalesińska, M. Górczewska, Pozn. Univ. Technol. Acad. J. Electr. Eng. **92**, 166-167 (2017)
9. J. Zabłocka, M. Zalesińska, K. Wandachowicz A. Raczak, Pozn. Univ. Technol. Acad. J. Electr. Eng. **96**, 209-218 (2018)