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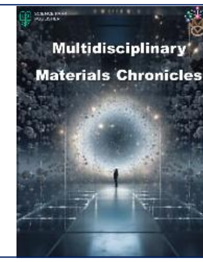

Multidisciplinary Materials Chronicles

Studying the performance of LED lamps during aging time

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Abstract

Understanding how LED lamp performance changes over time is essential for predicting both their operational efficiency and overall lifespan. Although LEDs are widely recognized for their long life and high energy efficiency, environmental conditions such as temperature fluctuations, humidity levels, and voltage variations can gradually reduce their performance. In experimental settings, LED bulbs are subjected to tests lasting hundreds or even thousands of hours, during which key parameters—including luminous flux, operating temperature, and electrical power consumption—are recorded. The data obtained from these tests support the development of predictive models for estimating lifespan and scheduling maintenance. Manufacturers can also utilize this information to enhance their design and production processes. This study specifically evaluates various types of indoor LED lamps over a 1,000-hour period, comparing their electrical, photometric, and radiometric characteristics to identify which model performs best. The results indicate that, while these lamps provide high efficacy and satisfactory lumen output, their wattage, power factor, and current levels vary depending on the lamp type.

Keywords: LED lamps; Flux; Aging time; Electrical parameters

1. Introduction

Several elements contribute to the aging process of LED bulbs, such as ambient temperature, relative humidity, and the levels of electrical current and voltage applied. Higher temperatures tend to speed up the aging mechanism, whereas environmental humidity leads to a slower but continuous decline in performance [1-3]. For the purpose of this study, all measurements were conducted under controlled conditions set at 25 ± 1 °C with a humidity level of 50%. Operating the LED chip beyond its recommended current and voltage limits introduces electrical stress, which in turn causes early deterioration. LED technology is commonly employed for indoor illumination applications. The current study evaluates several electrical, light-related (photometric), and selected radiation-based (radiometric) characteristics of LED lamps. Since these lamps consist of multiple internal components, various types of energy losses may occur within them [4-6].

1.1. Driver electronics

An LED driver is an electrical device that regulates power to an LED or a string of LEDs. It is a crucial piece of an LED circuit, and to operate without one will result in system failure. LED drivers convert AC to DC and subsequently supply a constant. All LED lights need an LED driver to convert the mains power supply, which provides a much higher voltage than the constant direct current of 12V or 24V that LEDs require, into a more suitable one. This helps to prevent burnout and can lower the risk of fire. [7-9].

1.2. Optics

Under standard operating conditions, LEDs typically emit light across a viewing angle of approximately 120 degrees. For applications that demand a more concentrated beam, a secondary optical element is often placed directly over the LED. This component directs the light internally to produce

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various beam shapes, including spot, medium spot, wide spot, or elliptical spot patterns. As a result, most commercial LED lamps incorporate secondary optics such as lenses, reflectors, or total internal reflection (TIR) optics. These elements are designed to capture nearly all the light emitted by the LED and enhance its luminous intensity. Among the available options, the convex lens positioned around the LED remains the most commonly used type. Nevertheless, ongoing technological advancements have led to the growing popularity of other lens varieties as well.

In addition to optical components, the performance of an LED lamp depends heavily on its driver electronics, also referred to as the power supply unit. This component is responsible for converting the standard mains voltage into the specific operating voltage required by the LED. The internal design of these electronic circuits varies from one manufacturer to another, and their energy conversion efficiency typically ranges between 70% and 90% [13, 14].

1.3. Power factor

The concept of power factor applies specifically to alternating current (AC) electrical systems. Its value always falls between 0 and 1.0, with higher numbers indicating a better or more efficient power factor. The importance of the power factor stems from the fact that utility companies supply customers with volt-amperes, yet calculate their bills based on watts. The mathematical relationship is expressed as watts equals volts multiplied by amperes multiplied by the power factor ($P = V \times I \times PF$). Consequently, any power factor below 1.0 forces the utility to generate more volt-amperes than the theoretical minimum required to deliver the actual power measured in watts. This excess generation leads to increased costs in both electricity production and transmission. A power factor above 0.85 or 85% is generally considered acceptable. Utility providers often impose financial penalties on customers whose overall building electrical systems fail to maintain a power factor at or above this threshold [15-17].

Regarding the overall efficiency of an LED lighting system, the LEDs installed within the light source play the most significant role. The critical factor in this regard is the amount of light that can be successfully extracted from the semiconductor material into the surrounding environment. Additionally, the optical components used inside an LED light source—such as lenses and color filters—also affect the overall system efficiency. For instance, special diffusing lenses are often employed to achieve a specific beam angle for a given lamp. Nevertheless, the efficiency of these optical components remains very high when compared to that of the LEDs. Lighting continues to account for the largest share of household electricity consumption. Before being placed into service, LED lamps should operate reliably for a minimum of 1,000 hours. In this study, lamps from three different companies available in the Egyptian market are examined, labelled as T, V, and E. Among these, models T1, V1, and E1 are rated at 9 watts; models T4, V4, and E4 are rated at 12 watts; and models T7, V7, and E7 are rated at 15 watts, as illustrated in Figure 1.

Figure 1. The LED lamps.

2. Experimental

2.1. Aging cycles

The lamp aging process was conducted under stable environmental conditions within a specialized laboratory facility. The temperature inside the aging area was maintained at 25 ± 1°C. The lamps were mounted on a wall and operated in their designated orientation, with the light directed downward. Each lamp was connected to a power supply located inside an integrating sphere. The switching process—both turning the lamps on and off—was performed manually. For all lamp groups tested, a duty cycle consisting of 11 hours of continuous operation followed by 1 hour off was applied throughout the aging procedure.

2.2. Integrating sphere-based method for Luminous flux measurement

Figure 2 shows that the integrating sphere is hollow, with its interior coated with a very stable, diffuse-reflecting material, demonstrating that it is suitable for carrying out measurements of luminous flux. The sphere has a port for the LED lamp and a baffled port for the detector. The integrating sphere consists of a cosine-corrected photometer equipped with a *V(λ)* filter from the LMT company. The detector has a linear response with arange of 16–28 nA/lx, based on these characteristics, the total luminous flux of tested lamps can be measured in direct substitution with that of standard lamps. The sphere wall is coated with barium sulfate paint, which has a diffuse reflectance of approximately 97% in the visible region. The integrating sphere was also equipped with a tungsten auxiliary lamp (100 W) on the sphere wall to measure the self-absorption effects of the lamp in the sphere. The room temperature of the photometry laboratory was controlled to be about 24 °C. A temperature sensor is mounted to measure the air temperature inside the sphere. During lamp operation, the ambient temperature in the sphere was approximately 25 °C.

2.3. AC power supply for electrical parameters

Figure 3 shows an Agilent AC power supply used to measure the electrical parameters.

2.4. The UV radiometer

A UV radiometer is a precision instrument used to measure the intensity of ultraviolet (UV) radiation across specific wavelength bands (UVA, UVB, or UVC).

2.4.1. Key features

- Sensor probe with photodiodes and optical filters to detect targeted UV wavelengths
- Digital display showing readings in mW/cm², W/m², or UV Index
- High accuracy with built-in calibration and minimal interference from visible light

2.4.2. Main uses

- Monitoring UV curing in industrial printing and coatings
- Testing UVC sterilizers and medical phototherapy devices
- Measuring solar UV radiation for environmental and agricultural studies
- Ensuring workplace safety by assessing UV exposure risks

2.4.3. Operation

Simply point the sensor at the UV source, select the wavelength range, and read the instant value on the screen. Figure 4 shows the UV radiometer.

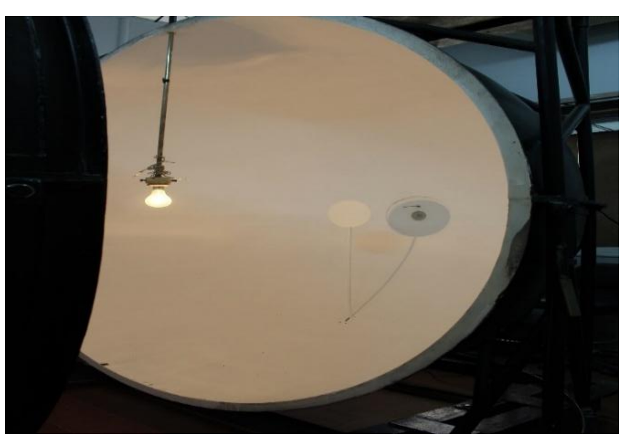

Figure 2. 2.5 m integrating sphere for photometric measurements.

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Figure 3. The AC power supply for electrical parameters measurements.

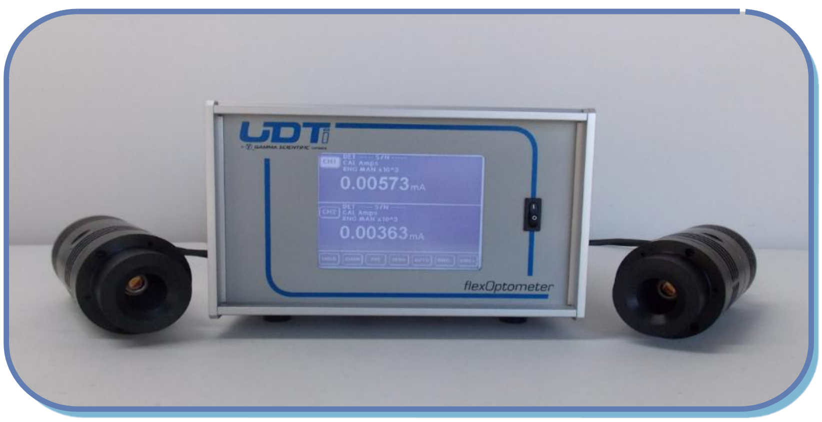

Figure 4. The UV radiometer.

3. Results and discussion

Figures 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16 show the variation of flux, power, current, and power factor for three types of lamps.

As shown in Figures 5 to 7 for the 9-watt lamps, the E1 lamp had the highest flux, while the T1 lamp had the highest wattage and V1 the lowest. The current E1 was the highest, while T1 was the lowest and V1 was in between. The power factor of T1 was higher than that of E1 and V1. In Figures 8 to 11 for the 12-watt lamps, E4 and V4 had the same or higher flux than that of T4. The wattage of T4 was the highest, V4 the lowest, and E4 moderate. The current E4 is the highest, T4 the lowest, and V4 intermediate. The power factor of T4 is higher than that of E4 and V4.

While in Figures 12 to 16 for the 15-watt lamps, the luminous flux of E7 was the highest, while V7 was intermediate, and T7 was the lowest. The wattage of E7 was the highest, V7 the lowest, and T7 moderate. The current of E7 was the highest, V7 the lowest, and T7 intermediate. The power factor of T7 was the highest, V7 the lowest, and E7 intermediate. Overall, it appears that each lamp has a unique combination of flux, wattage, current, and power factor, which may make it more suitable for specific applications or environments. It's important to consider all of these factors when selecting a lamp for a particular lighting need. Additionally, this effect, such as the increase in temperature and the increase in the current, increases the forward voltage across the diode, resulting in higher power loss. The LED temperature will rise due to power dissipation, reducing light output and efficiency. For UV and IR measurements, the values of all lamps were within safe limits. According to the previous conclusion, E1 is suitable for 9-watt LED lamps, E4 and V4 for 12-watt lamps, and E7 for 15-watt lamps in compliance with NIS working standards.

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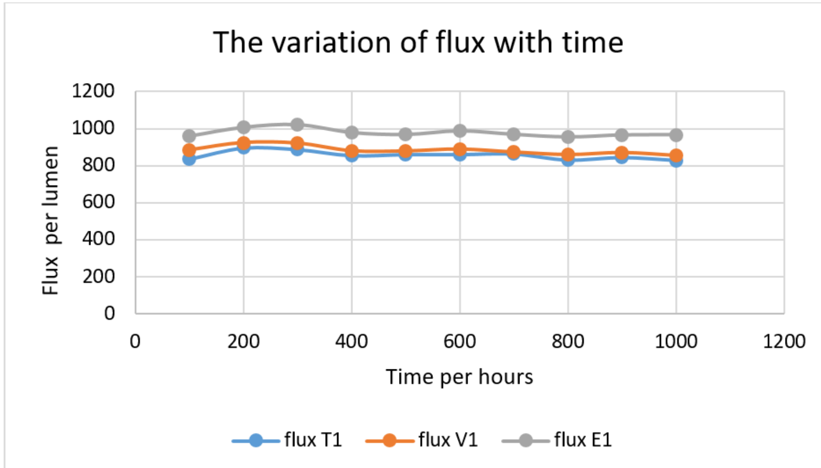

Figure 5. Variation of flux with time for 9-watt lamps.

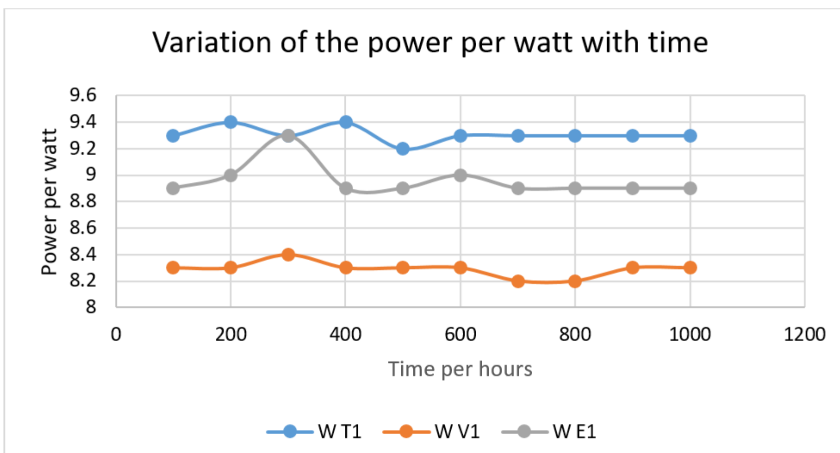

Figure 6. Variation of wattage with time for 9-watt lamps.

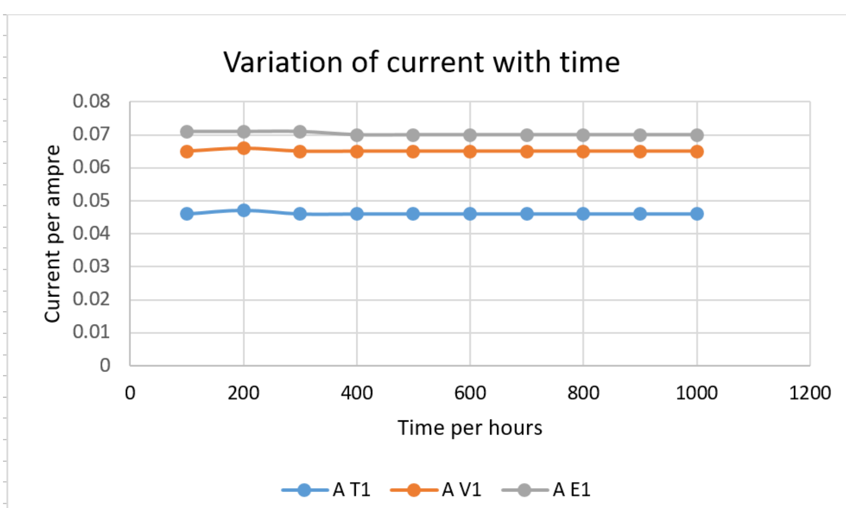

Figure 7. Variation of current with time for 9-watt lamps.

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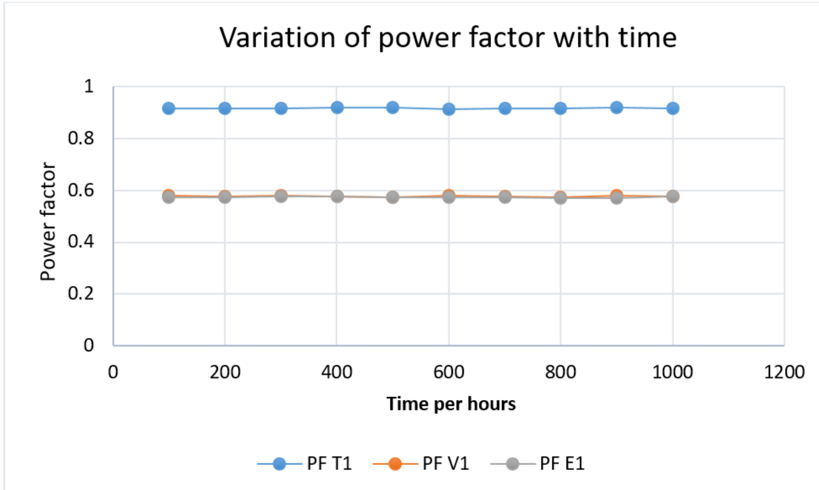

Figure 8. The variation of power factor with time for 9-watt lamps.

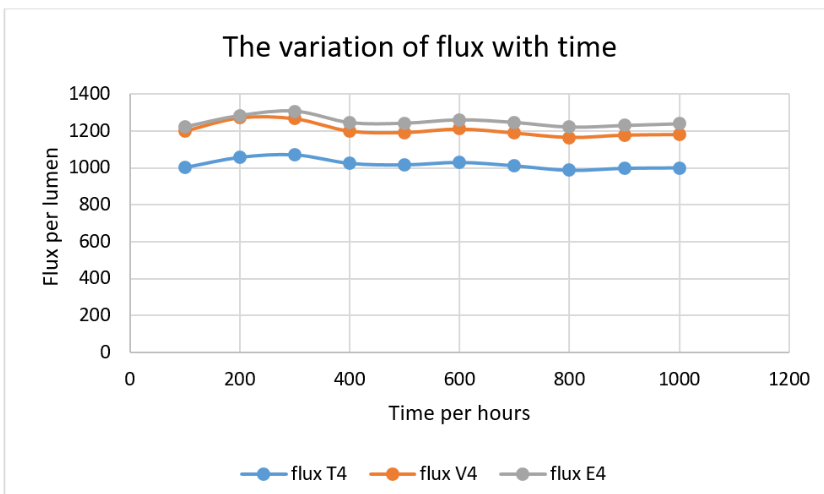

Figure 9. Variation of flux with time for 12-watt lamps.

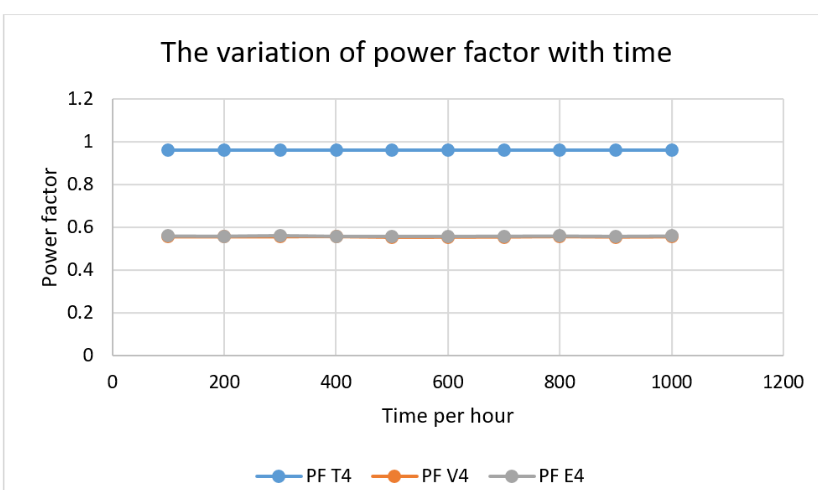

Figure 10. The variation of power factor with time for 12-watt lamps.

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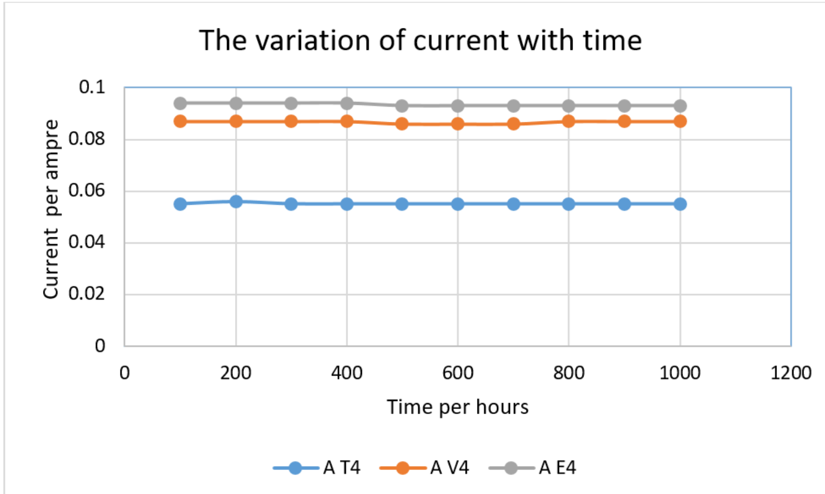

Figure 11. The variation of current with time for 12-watt lamps.

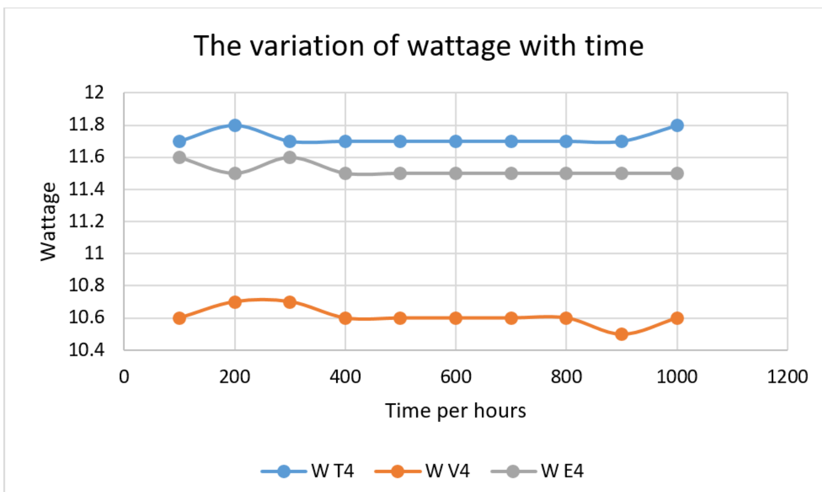

Figure 12. The variation of wattage with time for 12-watt lamps.

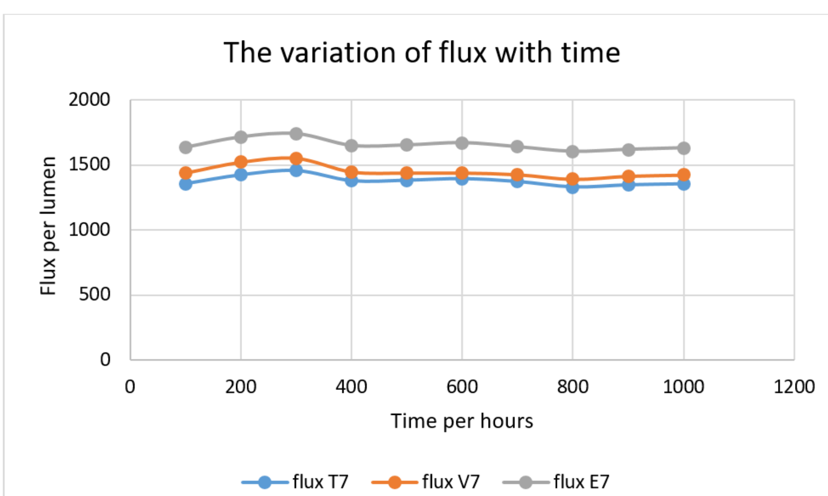

Figure 13. The variation of luminous flux with time for 15-watt lamps.

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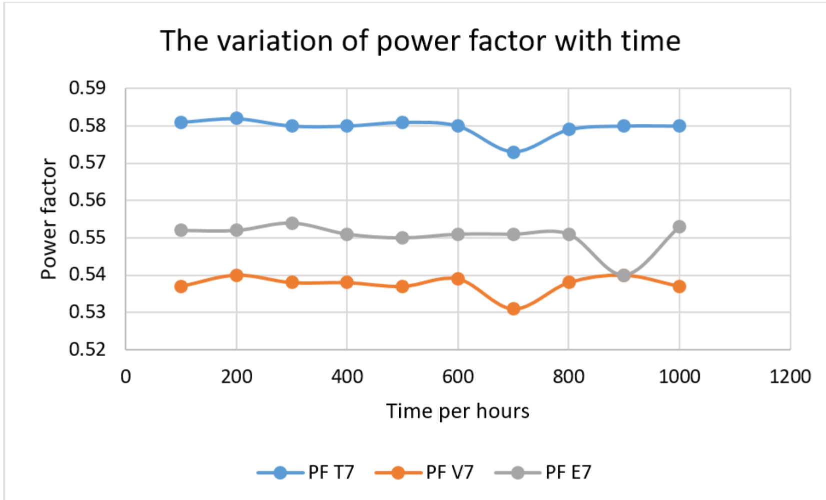

Figure 14. The variation of power factor with time for 15-watt lamps.

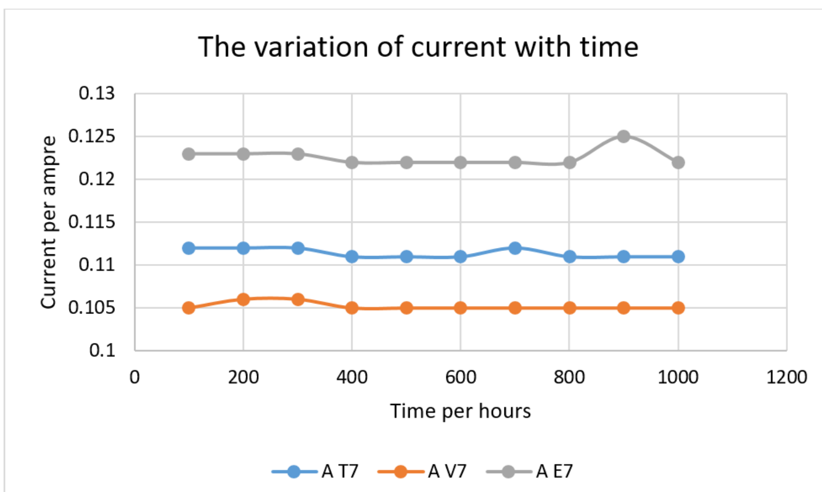

Figure 15. The variation of current with time for 15-watt lamps.

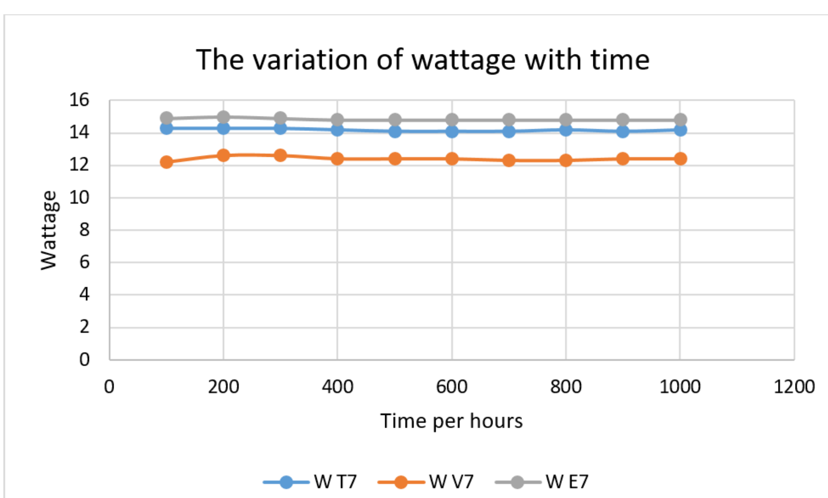

Figure 16. The variation of wattage with time for 15-watt lamps.

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4. The values of UV and IR for different lamps

Table 1 shows that the UV and IR emissions emitted by LED lamps vary with the specific LED type and design. However, LED lamps generally emit very little UV light and almost no IR light. UV light is generally undesirable in lighting applications because it can damage the skin and eyes with prolonged exposure. As a result, LED lamps are designed to emit a very small proportion of UV light, usually less than 0.1% of their total output. IR light, on the other hand, is often used for heating, but is undesirable for lighting purposes, as it can cause discomfort and degrade the color rendering of objects. LED lamps emit very little IR radiation, typically less than 5% of their total output.

It is worth noting that the UV and IR radiation levels for LED lamps can vary depending on the specific product and its intended use. In this work, we utilized LED lamps for illumination applications, and no UVC radiation was detected. Table 2 shows the summary of results, where, according to Egyptian standard specification 7773 / 2016 and IEC: 62612 /2015, we found that E1 is suitable for 9-watt LED lamps, while E4 and V4 are suitable for 12-watt lamps, and E7 is suitable for 15-watt lamps in accordance with the working protocols of NIS.

Table 1. The spectral irradiance in UVA and IR readings for different lamps.

Lamp	The spectral irradiance in UVA at 20 cm	The spectral irradiance in at 1 m	IR at 1m at T= 30 ºC λ=1310
T7	0.3 μw/cm^2	24 nw/cm^2	
V7	0.32	26.00	0.445
E7	0.61	41.60	0.753
T4	0.25	20.80	0.390
V4	0.27	22.70	0.407
E4	0.44	32.30	0.598
T1	0.17	17.10	271.1 nw/cm^2
V1	0.20	19.19	0.325μw/cm^2
E1	0.33	27.05	0.490μw/cm^2

Table 2. The summary of the results.

Criteria	The best		
Flux	E1	E4-V4	E7
current	E1	E4	E7
watt	T1	T4	E7
PF	T1	T4	T7

5. Conclusion

Based on the comparative analysis of LED lamp performance at NIS, for 9-watt lamps, E1 is the optimal choice, as it delivers the highest luminous flux and current, despite its intermediate power factor and wattage. For 12-watt lamps, both E4 and V4 are equally suitable, offering the same maximum flux, with E4 drawing higher current and V4 drawing lower wattage. For 15-watt lamps, E7 is the preferred option, delivering the highest flux and wattage, while V7 also performs well, offering higher flux than T7. Overall, each lamp type presents a distinct combination of flux, wattage, current, and power factor, making them suitable for different applications. However, the selected lamps (E1, E4/V4, and E7) meet the operational standards of NIS and provide the best balance between the light output and electrical performance.

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Authors' contributions

The author contributed to the study conception, design, data collection, analysis, and manuscript preparation.

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The author reviewed and approved the final version of the manuscript.

Conflict of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be available on request.

References

[1] S. Di Mauro, A. Raciti, S.A. Rizzo, G. Susinni, S. Musumeci, Effects of the aging time on CFL and LED lamps: Experimental tests on the electrical and photometric quantities, in: 2018 AEIT International Annual Conference, IEEE, Catania, Italy, October 2018, pp. 1–6. https://doi.org/10.23919/AEIT.2018.8577281.

[2] N. Rolamo, LED lamps - photometric and electrical performance, [Unpublished Master Thesis], Department of Electrical Engineering and Automation, Aalto University, Espoo, Finland, 2014.

[3] G.M. Dousoky, Z.M.M. Ali, A.M. El-Sawy, An experimental evolution of photometric performance and power quality of led lamps in different operating conditions, J. Adv. Eng. Trends 39(2) (2020) 157–166. https://doi.org/10.21608/jaet.2020.96454.

[4] Illuminating Engineering Society (IES), Guide to Lamp Seasoning, IES Standard LM-54-12, New York, 2012.

[5] International Commission on Illumination (CIE), Photobiological safety of lamps and lamp systems, CIE Standard S 009/E:2002, Vienna, Austria, 2002.

[6] S. Pimputkar, J.S. Speck, S.P. DenBaars, S. Nakamura, Prospects for LED lighting, Nat. Photon. 3(4) (2009) 180-182. https://doi.org/10.1038/nphoton.2009.32.

[7] J.D.D Unión-Sánchez, M.J. Hermoso-Orzáez, M.J. Hervás-Pulido, B. Ogáyar-Fernández, I. Fryc, T. Ścieżor, Impact of thermal dissipation on the lighting performance and useful life of LED luminaires applied to urban lighting: A case study, Int. J. Environ. Res. Public Health 19(2) (2022) 752. https://doi.org/10.3390/ijerph19020752.

[8] G. Sun, Y. Bai, Z. Zhang, Overview of high-power LED life prediction algorithms, Front. Sustain. Energy Policy 3 (2024) 1343339. https://doi.org/10.3389/fsuep.2024.1343339.

[9] J. Askola, H. Baumgartner, T. Pulli, P. Kärhä, E. Ikonen, Influence of smart lighting control on the lifetime of high power LED luminaires, IOP Conf. Ser. Earth Environ. Sci. 352(1) (2019) 012043. https://doi.org/10.1088/1755-1315/352/1/012043.

[10] W. Deng, D. Zhang, X. Zheng, X. Ye, X. Niu, Z. Lin, M. Fu, S. Zhou, Adsorption recovery of phosphate from waste streams by Ca/Mg-biochar synthesis from marble waste, calcium-rich sepiolite and bagasse, J. Clean. Prod. 288 (2021) 125638. https://doi.org/10.1016/j.jclepro.2020.125638.

[11] B. Sun, Y. Shen, Z. Zhang, C. Guo, C. Cui, A lifetime prediction approach for LED packages in paralleled under thermal-electronic coupling effects, Microelectron. Reliab 142 (2023) 114904. https://doi.org/10.1016/j.microrel.2023.114904.

[12] X. Yang, B. Sun, Z. Wang, C. Qian, Y. Ren, D. Yang, Q. Feng, An alternative lifetime model for white light emitting diodes under thermal–electrical stresses, Materials 11(5) (2018) 817. https://doi.org/10.3390/ma11050817.

[13] H. Zhao, F. Zeng, L. Lu, G. Hou, L. Lu, X. Zhang, Y. Jiang, W. Yuan, Y. Tang, Research on accelerated aging test and lifetime prediction of LED headlamp modules under temperature-humidity condition, Electro-Mech. Eng. 41(6) (2025) 1-8. https://doi.org/10.19659/j.issn.1008-5300.20251125001.

[14] W. Chen, J. Fan, C. Qian, B. Pu, X. Fan, G. Zhang, Reliability assessment of light-emitting diode packages with both luminous flux response surface model and spectral power distribution method, IEEE Access 7 (2019) 68495-68502. https://doi.org/10.1109/access.2019.2916878.

[15] H. Cao, Z. Ma, B. Sun, X. Sun, C. Yang, X. Li, J. Wang, L. Zhao, Composite degradation model and corresponding failure mechanism for mid-power GaN-based white LEDs, AIP Advances 8(6) (2018) 065108. https://doi.org/10.1063/1.5027783.

Multidisciplinary Materials Chronicles, 2026, Vol. 3, Iss. 1, 166-176

DOI: 10.62184/mmc.jmmc1100202535

[16] G. Sun, Y. Bai, Z. Zhang, Overview of high-power LED life prediction algorithms, Front. Sustain. Energy Policy 3 (2024) 1343339. https://doi.org/10.3389/fsuep.2024.1343339.

[17] C. Gong, H. Xu, Z. Yuan, J. Liang, The accelerated life test investigation and lifetime prediction method for LED Driver, in: 2022 5th International Conference on Power and Energy Application (ICPEA), November 18-20, 2022, pp. 335-359. https://doi.org/10.1109/ICPEA56363.2022.10052233.