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ASSESSMENT OF ARGENTINEAN LED LUMINARIES FOR STREET LIGHTING

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ABSTRACT

The work presents a statistical summary of the results obtained in the photometric, thermal, chemical and mechanical tests carried out in the Laboratorio de Acústica y Luminotecnia (LAL) for street lighting luminaires with LED technology in the period 2017/18. The study covers 152 luminaires and includes samples from different manufacturers or origin, same type or model (for example, a same body) with different alternatives of LED plates. The results of luminance and illuminance evaluations carried out in converted facilities (or in the test stage) are also discussed. The results presented are important both for importers and manufacturers of LED luminaires and for designers and installers, since they allow visualizing the points that deserve attention in order to achieve a product of suitable quality.

Keywords: LED, energy efficacy, street lighting

1. INTRODUCTION

The new PLAE (Plan for efficient lighting), from the Ministry of Energy and Mining under the Nation Presidency, proposes the luminary replacement for more efficient devices with LED technology. It consists of a state funding for conversion to LED technology, with the main objective of reducing consumption in street lighting. The PLAE sets technical specifications [1], which define the minimal requirements, must meet up by devices have to be installed. These technical specifications resulted from discussions with different experts involved in this sector: Lighting Argentinean Association (Asociación Argentina de Luminotecnia – AADL), Deputy Office of Public Services of Buenos Aires Province, national and provincial laboratories, etc., and they were based on the current national standards, such as IRAM AADL J 2021, J2022, J2028, J2020 [2, 3, 4, 5].

In this framework, LAL–CIC, as one of the accredited laboratories for carrying out technical tests, studied an important deal of national and imported samples. In its specifications, PLAE added special tests of duration, thermal stress and cycling to the traditional photometrical, mechanical, thermal and spectral tests, based on IRAM AADL standards. The results obtained have been dissimilar, verifying that the local standards are not comparable to other markets.

2. TESTS REQUESTED IN THE PLAE FRAMEWORK

The required tests are listed in the Technical Specifications of the plan [1]. They involve a set of tests taken mostly from Standard IRAM AADL J 2021 [2], which are shown in Table 1.

In addition, it is compulsory to verify the cover impact strength, according to Standard IEC62262–2002[6]: IK=8 or higher for glasses and IK=10 or higher for polymers.

As it is observed in Table I, the required tests can be considered as the typical ones that are applied in our country. In this sense, it is worth mentioning

Table1. PLAE Tests

Requirement and Test	Description
IRAM AADL J 2022–1	Photometry
4.1–3 and 5.1–3	Salt spray for complete luminaire (240 h)
4.4 and 5.4	Gear winding resistance
4.6 and 5.6	Adhesiveness of the paint coats
4.7 and 5.7	Resistance to the indentation of paint coats
4.8 and 5.8	Accelerated thermal aging of joints in elastomeric material
4.10 and 5.10	Vibration
4.11 and 5.11	Impact
4.12 and 5.12	Plastic deformation of elements in plastic material
4.13 and 5.13	Torsion resistance of threaded superior connection luminaries
4.14 and 5.14	Torsion resistance of lateral connection luminaries
4.15 and 5.15	Fixation system of luminaries mounted in suspension
4.20 and 5.20	Thermal shock for glass covers
4.22 and 5.22	Crush resistance in closing joints
4.24–25 and 5.24–25	Rain water tightness and dust tightness of the device unit housing
4.24–25 and 5.24–25	Rain water tightness and dust tightness of the optical housing
4.27 and 5.27	Main connection block
4.29 and 5.29	Hail
4.39 and 5.39	Grounding
Aditional test	Thermal stress
Aditional test	Ignition Cycle
Aditional test	Luminous flux maintenance in time, assessment of CCT and colour rendering index R_a
Aditional test	Weight determination of the complete luminaire

that they are mainly based on [2], whose first version is from 1974. The novel nature of PLAE is the flux maintenance test, which tries to evaluate the expected duration for LED luminary and whose details are further commented.

3. GENERAL FEATURES OF THE MAIN TESTS

3.1. Photometry and Colour

Photometry is the test with a strong tradition in Argentina. Based on the IRAM standard [3], standardization dates back to the mid-70s. LED luminaires introduced two changes in the norm (2013): the use of absolute values for intensities and efficacies, and the spectra radiometric measurements for colour parameters, for example. Figs. 1 and 2 show the LAL equipment and characteristic results of this test.

3.2. Paint Quality Tests

The salt spray test refers to IRAM 121 [7] from 1957. The test is based on an old version of ASTM 117 [8] and consists of putting the complete sample to a salt environment in order to verify the level of mechanical protection given by protecting coatings (paints). The requirement is regulated by the length of the test, 240 h is the minimal time indicated by IRAM for paints, though it can be extended to 500 h or 1000 h in special situations and/or by agreement between suppliers and buyers, (the typical case is the installation in sea coast zones). The result is assessed by inspection in frame of our standard, which not allowing coating blisters or lifting, and by no means, oxidation or cracking of base material, either. Fig. 3 shows LAL equipment and examples of studied samples.

In connection to this test, it then follows the resistance test to the gear of threaded pieces, which

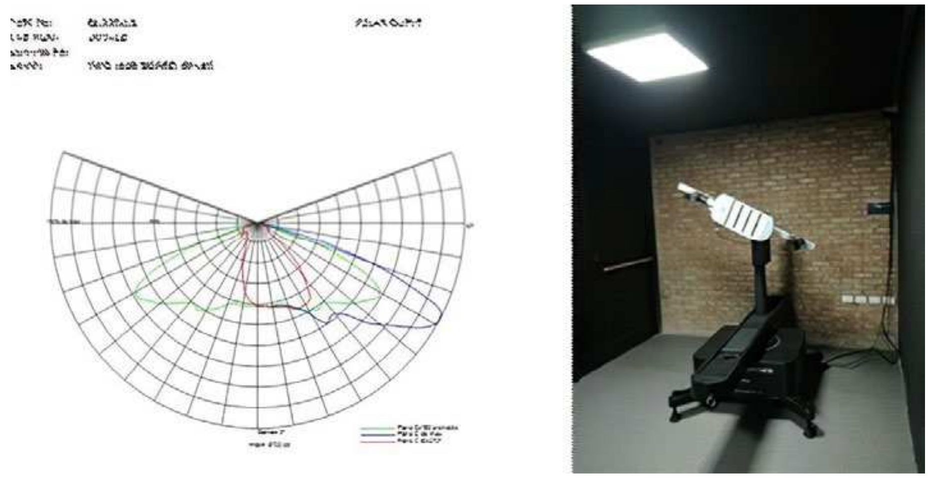

Fig. 1. An example of photometric results and LAL equipment

consists of practically verifying that the anchoring or fixation screws can be removed without difficulties after exposure to salt environment by using the suitable tools for this work.

As a complement, adhesiveness and resistance to indentation of paint coats are checked in order to determine the coating quality and its fixation to the base. In this sense, a low-quality paint or badly applied will not guarantee the protection needed for the coated material and will be detrimental for the product lifetime.

3.3. Another Mechanical and Electrical Tests

The vibration test uses a machine capable of inducing an acceleration of 2 g in the most requested point of the luminaire, during a span of 100,000 cycles ± 1,000 cycles at the resonance frequency in order to determine the clamp fixation capacity and the mechanical resistance of all the luminary components. With the same equipment, the impact to vibration, with an acceleration of 4 g in the most requested point of the luminary, allows determining the sample behaviour against accidental impacts during its transfer and installation.

It is also worth highlighting the dust tightness test and water tightness of the optical unit and the behaviour of the auxiliary equipment, Fig. 4. Both are intended to assess the closing of different compartments, linked directly with the duration of the device. This test, commonly known as IP degree is also based on an older standard: IRAM 2444 [9].

Finally, we would details more on tests related to electrical safety, terminal boards and grounding verification. The latter uses a source of low-voltage direct current, with which a current of at least 10 A is made circulate between the luminaire ground terminal and each reachable metallic part. The resis-

Table 2. Typical Powers and Efficacies

LED Technology	LED Power, W	Luminous efficacy, lm/W
COB	34–66	110–150
SMD MID	0.26–0.95	108–141
SMD	2.2–3.3	120–155

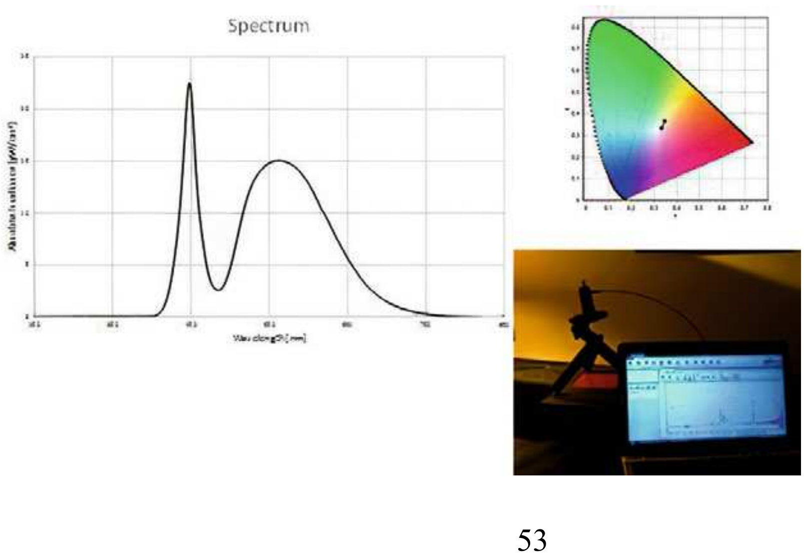

Fig. 2. Example of spectra and colour test

Fig. 3. LAL salt fog test equipment and results (photos from author)

tance value should not be higher than 0.20 Ω, what forces to a design that must address the cover wiring and mobile parts.

3.4. Product Lifetime Estimation

Three tests are combined in this verification, which are worth highlighting for being exclusive for LED products:

a. Thermal stress, which consists of exposing the luminaire off for an hour at a temperature of –10 °C and immediately afterwards at a temperature of 50 °C for an hour, repeating the cycle five times.

b. Cycling, which puts the luminaire under a test of 5,000 on and off cycles (both of 30 s), being carried out after the thermal stress test.

After completion of both tests, the luminary must continue working without apparent damages.

c. Luminous flux decay in time, assessment of correlated colour temperature CCT and colour rendering index CRI, which consists of carrying out an "aging" of the luminary by means of its continuous operation for 6,000 h, period after which the decrease of the emitted luminous flux and the CCT change with respect to the initial value previous to aging are verified, Fig. 5.

4. RESULTS

It is noteworthy the distribution of products in function of the different LED luminaire technologies for street lighting. Fig. 6 shows this distribu-

Fig. 4. IP test: air (left) and water tightness (right) (photos from author)

Fig. 5. Aspects of 6,000 h operation test (photo from author)

Table 3. Installation Assessment

Installation 1	**E_{av}, lx**	**Power in the area, W**	**Density of normalized power, W/(m²· lx)** (6 m × 39 m)
Original (HPS250)	7.6	2 × 250 = 500 +10 % = 550	0.309
Reconverted (LED150)	27.1	2 × 150 = 300	0.047

Installation 2	**E_{av}, lx**	**Power in the area, W**	**Density of normalized power, W/(m²· lx)** (7 m × 30 m)
Original (SAP 250)	18.6	1 × 250 = 250 +10 % = 280	0.072
Reconverted (LED148)	32.0	1 × 139 = 139	0.021

tion for a total of 152 luminaires involved (the total includes the same type or model, but of different power or LED amount). The discriminated categories are COB (Chip on board), SMD MID (Surface mounted device, superficial assembly, medium power) or SMD (High power surface mounted device).

Even though the national recommendation about design [4] stipulates the use of a removable and interchangeable protecting covers, there are other options in the market. Fig. 7 shows the proportion between the different involved alternatives.

In Fig. 7, it is indicated "cover" when there is really an interchangeable and independent flat closing of the lens. "Lens" is referred to a refractor with focus optical functions and that it is also the LED protection, being able to be adhered, fixed with fasteners or screws and, though it can be removed, it is not intended for its change or replacement.

As a complement to the distributions indicated in Figs 1 and 2, Table 2 shows the typical power ranges by LED and global efficacies of the involved samples. The values between brackets correspond to glass covers. It is underlined that the last version of PLAE requirements admits a minimal luminous efficacy equal to 105 lm/W for luminaries having a protecting cover of the glass or polymer optical housing not including lens in it, and higher than or equal to 120 lm/W for luminaries without it.

Tests to the protecting cover: paint and salt spray are among those with more samples not passing the standards set by the norm. Statistics are shown in Fig. 8.

In the paint tests, lack of adherence was the recurrent failure. In salt spray (240 h), it was the oc-

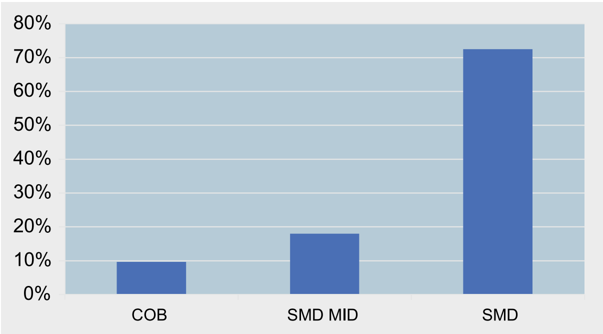

Fig. 6. Types of LED technologies

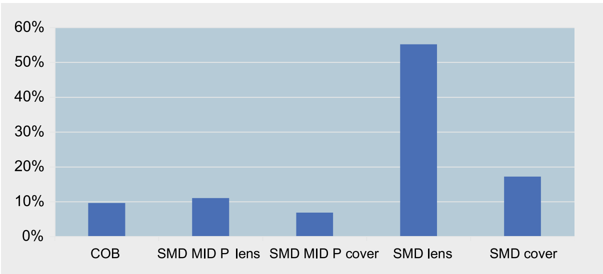

Fig. 7. Types of cover

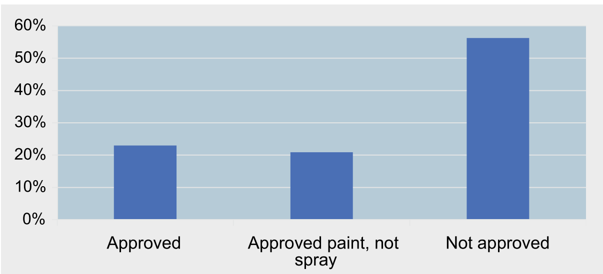

Fig. 8. Failures in salt spray and paint

currence of blisters, especially in zones near the clamps or fastening systems (joints between aluminum and iron alloys). To a lesser extent, oxidation of base material or screws was found.

The failures of water-tightness, mainly in housings for the auxiliary device, were also important. In most of the cases found, the opening systems of the "without tool" type (snap hooks or staples) did not apply enough pressure to ensure the closing. It must be highlighted the fact that the closings with screws, which allow a simpler and safer design for guarantying tightness, were numerous though they were not taken into account in the standard IRAM [4].

The percentage of failures in the rest of the tests was lower.

The recurrent problems were:

– Failures (breakage) in glass covers during IK8 test have shown that percentage was lower than 10 % of the studied samples and mainly affected flat refracting glasses assembled without frame.

– Between 20 % and 30 % with flaws in the wiring: lack of grounding continuity, terminal board with inadequate marking, lack of ground terminal.

– Roughly 30 % of the photometric tests did not verify the PLAE requirement ratio l_{max}/I_0 higher than 2 (I_0 luminous intensity for the zenith) and to an equal extent, the colour temperature was out of the required range (3000–4500) K.

4.1. Result in Installations

Here we mention only a couple of cases taken from the technical assistance supplied by the LAL to municipalities from Buenos Aires province. In these studies, it was possible to carry out a standardized assessment [10] of a new installation (with LED luminaries) and of zones with the previous system (High Pressure Sodium lamps, HPS). It must be pointed out that the original installation dated from the 90s, with minimal maintenance. Table 3 shows these results. Reference [11] has similar information for the case of highways and reconversions carried out in previous periods.

5. CONCLUSIONS

The whole analysis of the results and the origin of the tested products allow establishing a first conclusion: the local standards regarding global protection of the product (paint and resistance to corrosion) are higher than the mean of the other markets products. Moreover, it is observed an excessive focus on the assignment of high IP indexes (66) often unfulfilled by closings of joint systems.

Finally, it is outstanding the importance of establishing quality requirements, such as the PLAE requirements [1] since in some way they establish guidelines then followed by the private specification sheets from different buyers (town hall, cooperatives, etc). The final test of the converted installation is not so generalized (illuminance assessment according to standard); and this is a very important issue to be taken into account in order to really ensure the lighting system enhancement.

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