A review of published standards for light emitting diode (LED) technology in the South African National Standards (SANS), International Electro-technical Commission (IEC) and other international standards, as well as a report on the progress of some of these institutions' work groups.

Light emitting diode standards – where are we?

It is important to set guidelines pertaining to LED technology so that South African manufacturers and users can work to a common national goal until appropriate standards have been accepted and published by SANS.

Setting performance values and test procedures is difficult because of rapid change in the LED industry. In this article, we take a look at the Federation of National Manufacturers Associations for Luminaires and Electrotechnical Components for Luminaires in the European Union’s (CELMA’s) publication “Apples and pears, a CELMA guiding paper: why standardisation of performance criteria for LED luminaires is important.”

The paper suggests that, in the interim, South Africa should use an approved recommended practice (ARP) document published by the Illumination Engineering Society of South Africa (IESSA) or by SANS to provide information to local manufacturers and users.

The introduction of LEDs into the lighting market has made manufacturers and users rethink their lighting needs, test methods and the application of their existing equipment. This thinking also stems from the worldwide energy shortage, particularly here in South Africa. Although lighting consumes only about 17% of the country’s generated power, it contributes some 34% towards peak loads.

Some new entrants into the lighting market do not have the knowledge and test facilities required to provide quality light emitting diode (LED) product. Many of these lamps have not been on the market long enough to validate claims pertaining to their performance characteristics and there are a number of LED products entering the market at present under dubious, unproven and unsubstantiated claims. It has been found that many of the claims are based on findings made under ideal laboratory conditions, and not under the conditions of use.

LED standard terminology
The IEC has published some standards and two publicly available specifications.
These documents suggest that the following quality criteria should be considered when evaluating LED manufacturers’ claims:

**Rated input power**
The rated input power shows the amount of energy consumed by a luminaire, including its power supply. It is expressed in watt.

**Rated luminous flux**
This corresponds to the light emitted by the luminaire, expressed in lumen. For traditional luminaires, it is not very common to measure and publish the rated luminous flux. This is normally calculated as the lamp flux multiplied by the light output ratio (LOR) of the luminaire. To make a technical comparison between “traditional” and LED luminaires, it is recommended to take the actual application into account and compare both lighting designs.

**LED luminaire efficacy**
The measured initial luminous flux divided by the measured initial input power of the same individual LED luminaire. It is expressed in lumens per watt.

**Luminous intensity distribution**
The spatial distribution of the luminous flux is depicted graphically in a luminous intensity distribution curve, which is usually expressed in a polar coordinate diagramme representing the light intensity as a function of angle about a light source. It is expressed in cd = lm × sr⁻¹.

**Photometric code**
A six-digit photometric code that displays the important parameters of light quality: colour rendering index (CRI); correlated colour temperature (CCT); chromaticity co-ordinates and luminous flux. The photometric code of the LED module must published on the packaging of the product and in the product leaflet.

**Rated colour rendering index (CRI)**
The colour rendering of an LED module giving white light is the effect on the colour appearance of objects by conscious or subconscious comparison with their colour appearance under a reference illuminant.

**Correlated colour temperature (CCT)**
The colour temperature of an LED module giving white light is determined by comparing the light emitted by the LED module with light of an ideal black-body radiator at the given temperature. It is expressed in Kelvin.

**Rated chromaticity**
Rated chromaticity co-ordinates both initial and maintained values. It involves the behaviour of the chromaticity co-ordinates of an LED module expressed in measurement results of initial and maintained chromaticity co-ordinates.

**Lumen maintenance code**
The measured initial luminous flux (initial value) is normalised to 100% and used as the first data point for determining the LED module life. The maintained luminous flux (maintained value) is measured at 25% of rated lifetime up to a maximum of 6000 hours and expressed as a percentage of the initial value. The maintained value determines the lumen maintenance code (see Table 1).

**Rated life (Lx), rated lumen maintenance**
This signifies the length of time during which a population of LED modules provides more than the claimed percentage (x) of the initial luminous flux always published in combination with the failure fraction. It is expressed in hours.

**Failure fraction (Fy)**
This corresponds to the rated life of the LED module in the luminaire. The percentage (y) of a number of LED modules of the same type at their rated life designates the percentage (fraction) of failures. This failure fraction expresses

### Table 1: Lumen maintenance code at an operational time.

<table>
<thead>
<tr>
<th>Lumen maintenance (%)</th>
<th>Code</th>
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<tbody>
<tr>
<td>≥90</td>
<td>9</td>
</tr>
<tr>
<td>≥80</td>
<td>8</td>
</tr>
<tr>
<td>≥70</td>
<td>7</td>
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</table>
the combined effect of all components of a module including mechanical components, as far as the light output is concerned. The effect of the LED could either be less light than claimed or no light at all.

Ambient temperature (tq)

The ambient temperature around the luminaire, related to specified performance. For a given performance claim, ambient temperature (tq) is a fixed value. It is possible to specify performance claims at different ambient temperatures. It is expressed in degrees Celsius. It is important to specify the actual ambient temperature of where the LED is to be used.

Luminous flux

As the typical life of a LED luminaire is very long, it is time consuming to measure the actual lumen reduction over life (e.g. L70, indicating the length of time during which the LED module provides more than the claimed 70% of the initial luminous flux). The actual LED behaviour with regard to lumen maintenance may also differ considerably per type and per manufacturer. It is not possible to express the lumen maintenance of all LEDs in simple mathematical relations. A fast initial decrease in lumen output does not automatically imply that a particular LED will not make its rated life.

An extrapolation of test data is needed to validate a life time claim. In IEC, a general method of projecting measurement data beyond limited test time is under consideration. In the USA, an extrapolation based on LM-80 test data will be described in IES TM-21. Instead of life time validation, the IEC/PAS has opted for lumen depreciation categories as a defined, finite test time. Therefore, the code number does not imply a prediction of achievable life time. The categories are lumen-depreciation character categories showing behaviour in agreement with the manufacturer’s information, provided before the test is started. The maintained luminous flux is measured at 25% of rated life time up to a maximum of 6000 hours. The value classification for the photometric code is obtained by using one of the “lumen maintenance categories” (see Table 1).

Luminaire life claims

Luminaire life, on the other hand, has to do with the reliability of the components of an LED luminaire as a system, including the electronics, materials, housing, wiring, connectors, seals, etc. The entire system lasts only as long as the critical component with the shortest life, whether that critical component is a weather seal, an optical element, an LED or an electronic control gear circuit. From this point of view, LEDs are simply one critical component among many — although they are often the most reliable component in the whole lighting system (see Fig. 1).

If an LED luminaire is equipped with a replaceable LED module, the luminaire life can be decoupled from the LED module and its life. This brings luminaire life closer to the current definition of luminaire life for conventional light sources. For instance, the life of road lighting luminaires is often 30 to 40 years. It is, however, preferable to publish the LED module life as the LED luminaire life.

Reputable LED luminaire manufacturers spend a great deal of time and effort designing and developing all aspects of a lighting system, including control algorithms, board layouts, component quality, thermal management features, optics, and mechanical design.

The LED luminaire design is then typically validated through a series of laboratory tests to verify that the luminaire meets the expected performance levels for heat dissipation, light output, and so on. Since all the aspects of an LED luminaire are interdependent, operational performance can be determined only by testing the luminaire as an integrated system (see Fig. 2). According to the IEC/PAS 62722, LED luminaire life should always be published as a combination of life at-lumen maintenance (Lx) and failure fraction (Fy). The failure fraction expresses the combined effect of gradual and abrupt failure of all components of a luminaire, including mechanical components, as far as the light output is concerned. This means that the LED luminaire could either emit less light than claimed or no light at all.

Published standards

The following standards are available: International standards IEC. Annex B of IEC/PAS 62722 explains the current view on recommended life time metrics related to LED luminaire life (see Table 2).

International standards IES. These are additional standards which may be taken in consideration (see Table 3).

products – Illuminating Engineering Society of North America, 2008. LM-79 prescribes uniform test methods under controlled conditions for photometric and colorimetric performance, as well as electrical power measurements for LED luminaires manufactured for production. This can be used to measure the initial electrical and photometrical specifications of an LED luminaire.

- **IES LM-80-08.** Approved Method: measuring lumen maintenance of LED light sources – Illuminating Engineering Society of North America, 2008. LM-80 is about measuring lumen maintenance of LED light sources (package and array). It consists of a real measurement over the first 6000 hours combined with an extrapolation out to end of life. Many luminaire manufacturers will translate the maintenance curve of the LED light source into a maintenance curve of the LED luminaire using the TM-21 recommendations. There are two constraints in doing this: firstly, catastrophic failures of individual LEDs and other failure modes, which contribute to the depreciation of light output of a population of LEDs in an LED luminaire, are not taken into consideration. Secondly, there is no validated way to translate the lumen maintenance curve of individual LEDs into a curve for the LED luminaire.

- **IES TM-21-11.** Projecting long term lumen maintenance of LED packages – Illuminating Engineering Society of North America, 2011. TM-21 provides recommendations for projecting long term lumen maintenance of LED packages using data obtained when testing them to IES LM-80-08.

### International standards IEC scope

- **IEC TS 62504 Edition 1. Terms and definitions for LEDs and LED modules in general lighting.** This technical specification presents terms and definitions relevant for lighting with LED light sources. It provides both descriptive terms (“built-in LED module”) and measurable terms (“luminance”). Annex A gives an overview of systems composed of LED modules and control gear.

- **IEC 61347-2-13.** Publication 2006: LED control gear – safety. This part of IEC 61347 specifies particular safety requirements for electronic control gear for use on DC supplies up to 250 V and AC supplies up to 1000 V at 50 Hz or 60 Hz, and at an output frequency which can deviate from the supply frequency associated with LED modules. Control gear for LED modules specified in this standard is designed to provide constant voltage or current. Deviations from the pure voltage and current types do not exclude the gear from this standard. Note 1: The tests in this standard are type tests. Requirements for testing individual control gear during production are not included. Note 2: Requirements for control gear which incorporates a means for varying the output power are under consideration. Note 3: It may be expected that control gear complying with this standard will ensure satisfactory operation between 92% and 106% of the rated supply voltage, taking into account the specifications of the LED module manufacturer.

- **IEC 62560.** Edition 1, Publication 2010: publicly available specification – LED lamps – Safety. This international standard specifies performance requirements for electronic control gear for use on DC supplies up to 250 V and AC supplies up to 1000 V at 50 Hz or 60 Hz with an output frequency which can deviate from the supply frequency, associated with LED modules according to IEC 62031. Control gear for LED modules specified in this standard is designed to provide constant voltage or current. Deviations from the pure voltage and current types do not exclude the gear from this standard. Note 1: The tests in this standard are type tests. Requirements for testing individual control gear during production are not included. Note 2: Requirements for control gear which incorporates a means for varying the output power are under consideration. Note 3: It may be expected that control gear complying with this standard will ensure satisfactory operation between 92% and 106% of the rated supply voltage, taking into account the specifications of the LED module manufacturer.

- **IEC/PAS 62612.** Publicly available specification, LED lamps – Performance. This international standard specifies performance requirements for electronic control gear for use on DC supplies up to 250 V and AC supplies up to 1000 V at 50 Hz or 60 Hz with an output frequency which can deviate from the supply frequency, associated with LED modules according to IEC 62031. Control gear for LED modules specified in this standard is designed to provide constant voltage or current. Deviations from the pure voltage and current types do not exclude the gear from this standard.

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### Table 4: SANS LED Standards.

<table>
<thead>
<tr>
<th>Standard number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SANS 62384: 2008 / IEC 62384:2008</td>
<td>DC or AC supplied electronic control gear for LED modules – Performance requirements</td>
</tr>
</tbody>
</table>

### Table 5: SANS available standards.

<table>
<thead>
<tr>
<th>Standard number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC/PAS 62722-2-1 Public Available Specification</td>
<td>Performance requirements – LED Luminaires for general lighting</td>
</tr>
</tbody>
</table>
with LED modules according to IEC 62031. Control gear for LED modules specified in this standard is designed to provide constant voltage or current. Deviations from the pure voltage and current types do not exclude the gear from this standard.

Note 1: The tests in this standard are type tests. Requirements for testing individual control gear during production are not included.

Note 2: Requirements for control gear which incorporates means for varying the output power are under consideration.

Note 3: It may be expected that control gear complying with this standard will ensure satisfactory operation between 92% and 106% of the rated supply voltage, taking into account the specifications of the LED module manufacturer.

- IEC 62031 Edition 1. Publication 2008: LED Modules – Safety (accepted in South Africa). This international standard specifies general and safety requirements for LED modules without integral control gear for operation under constant voltage, constant current or constant power and for self-ballasted LED modules for use on DC supplies up to 250 V or AC supplies up to 1000 V at 50 Hz or 60 Hz. Note 1: The safety requirements for separate control gear are specified in IEC 61347-3. The performance requirements for separate control gear are specified in IEC 62384. Note 2: Requirements for LED modules with integrated control gear and equipped with a lamp cap (self-ballasted lamp), intended for mains voltage general lighting service retrofit applications (thereby replacing existing lamps with identical lamp caps) are specified in IEC 60968 (an amendment to the present edition or a new edition with extended scope is in preparation). Requirements for LED modules with integrated control gear and equipped with a lamp cap (self-ballasted lamp), intended for non-mains voltage general lighting service retrofit applications (thereby replacing existing lamps with identical lamp caps) are under consideration. Note 3: Where in the requirements of this standard both types of LED modules, with and without integral control gear, are addressed, the word “modules” is used instead. Where only the expression “LED module(s)” is used instead, it is understood to refer to the type without integral control gear.

- IEC/PAS 62717 Edition 1. Publicly available specification, LED modules – Performance. This PAS specifies the performance requirements for LED modules, together with test methods and conditions, required to show compliance with this PAS. The following types of LED modules are distinguished (see Fig. 3):
  - Self-ballasted LED modules for use on DC supplies up to 250 V or AC supplies up to 1000 V at 50 Hz or 60 Hz;
  - LED modules operating with external control gear connected to the mains voltage, and having further control means inside (“semi-ballasted”) for operation under constant voltage, constant current or constant power;
  - LED modules where the complete control gear is separate from the module for operation under constant voltage, constant current or constant power.

The power supply of the control gear for semi-ballasted LED modules is an electronic device capable of controlling currents, voltage or power within design limits. The control unit of the control gear for semi-ballasted LED modules is an electronic device to control the electrical energy to the LEDs. An LED module with external control gear can be either a non-ballasted LED module or a semi-ballasted LED module.


- IEC/PAS 62722-2-1 Publicly available specification, LED luminaires – Performance. This PAS specifies the performance requirements for LED luminaires, together with the test methods and conditions required to show compliance with the PAS. It applies to LED luminaires for general lighting purposes where claims of operational performance are made.

The following types of LED luminaires are distinguished:
  - Type A: Luminaires using LED modules that have not been shown to comply with IEC/PAS 62717.
  - Type B: Luminaires using LED modules that have been shown to comply with IEC/PAS 62717.
  - Type C: Luminaires using LED lamp and covered in IEC/PAS 62722-1.

The definition of the LED module is given in IEC/TS 62504. The requirements of this PAS only relate to type testing. This PAS does not cover LED luminaires that intentionally produce coloured light or luminaires using organic LEDs (OLEDs). These performance requirements are additional to the requirements in IEC/PAS 62722-1.

South African standards for LEDs


Compulsory standards include

SANS 60598-1:2009 edition 5 and compulsory standards include national amendment 1 IEC 60598-1:2008 Edition 7: Luminaires - Part 1: General requirements and tests specifies general requirements for luminaires, incorporating electric light sources for operation from supply voltages up to 1000 V.

The requirements and related tests of this standard cover classification, marking, mechanical construction and
electrical construction. Attention is drawn to the fact that this part 1 covers all aspects of safety (electrical, thermal and mechanical). The presentation of photometric data for luminaires is under consideration by the International Commission on Illumination (CIE) and is not, therefore, included in this part 1.

Requirements for semi-luminaires are included in this part 1. A self-ballasted lamp is defined as a unit which cannot be dismantled without being damaged permanently, provided with a lamp cap and incorporating a light source and any additional elements necessary for starting and stable operation of the light source.

In general, this part 1 covers safety requirements for luminaires. The object is to provide a set of requirements and tests which are considered to be generally applicable to most types of luminaires, and which can be called up as required by the detail specifications of IEC 60598-2. This part 1 is therefore not regarded as a specification in itself for any type of luminaire, and its provisions apply only to particular types of luminaires to the extent determined by the appropriate part of IEC 60598-2.

The parts of IEC 60598-2, in making reference to any of the sections of part 1, specify the extent to which that section is applicable and the order in which the tests are to be performed; they also include additional requirements as necessary. The order in which the sections of part 1 are numbered has no particular significance as the order in which their provisions apply is determined for each type of luminaire or group of luminaires by the appropriate part of IEC 60598-2. All parts of IEC 60598-2 are self-contained and therefore do not contain references to other parts of IEC 60598-2.

For explosion proof luminaires, covered by IEC 60079, the requirements of IEC 60598 (selecting the appropriate parts 2) are applied in addition to the requirements of IEC 60079. In the event of any conflict between IEC 60598 and IEC 60079, the requirements of IEC 60079 take priority.

SANS 60968:2006 Edition 1.2/IEC 60968:1999 Edition 1.2: Self-ballasted lamps for general lighting services – Safety requirements specifies the safety and interchangeability requirements, together with the test methods and conditions, required to show compliance of tubular fluorescent and other gas discharge lamps with integrated means for controlling starting and stable operation (self-balled lamps), intended for domestic and similar general lighting purposes, having a rated wattage up to 60 W; a rated voltage of 100 to 250 V and Edison screw or bayonet caps.

The requirements of this standard relate only to type testing. Recommendations for whole product testing or batch testing are under consideration.

SANS 60969:2010 Edition 1: Self-ballasted lamps for general lighting services – Performance requirements specifies the performance requirements together with the test methods and conditions required to show compliance of tubular fluorescent and other gas discharge lamps with integrated means for controlling starting and stable operation (self-balled lamps) intended for domestic and similar general lighting purposes having a rated wattage up to 60 W, a rated voltage of 100 to 250 V and Edison screw or bayonet caps.

The requirements of this standard relate only to type testing. Recommendations for whole product testing or batch testing are under consideration. These performance requirements are additional to the requirements in IEC 60968.

Priority needs

The following standards are urgently needed in South Africa to set a safe standard for the industry:

Double-capped LED lamps for general lighting services – Safety specifications

IEC 34A WG is working on this standard and we in South Africa should be doing the same as LED tubes are being offered for sale without any consideration for safety or performance.

Performance requirements – LED luminaires for general lighting

South Africa has accepted the IEC safety standard but we now need the performance part. We can accelerate the acceptance and publication of these new product standards by means of working groups using the IEC draft documents as a basis, developing our own standards. These may have to be published as IESSA guides or, even better, as approved recommended practice (ARP) documents with the understanding that these may be changed or withdrawn completely when an acceptable standard is published and accepted.

Conclusion

LED technology is advancing at a fast rate and is continually improving, so the standards are being left behind or, when published, are out of date. We need a way for the lighting industry to publish information to make manufacturers and users aware of potential problems of safety; to determine and define methods to avoid these safety issues, and to be able to specify the products for performance and prescribe test methods to validate safety and performance even if these are not complete or final. Is it not better to offer some guidance than to not say anything?

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References


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