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Solid-State Lighting Photometry Issues

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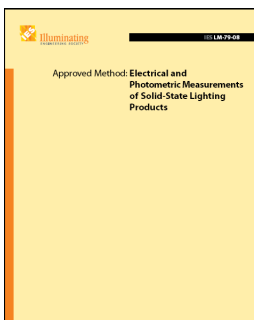
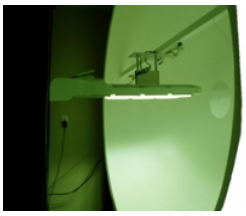
Introduction

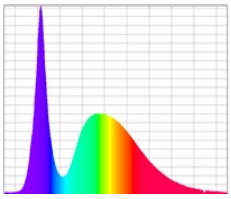
The basic measurement done in lighting product photometric test is the luminous intensity at specific planes and angles. Two different methods are used for testing lighting products. The first method is called “Relative Photometry” while the second one is called “Absolute Photometry”. The definitions and differences between these two methods are described in IESNA reference documents and publications.

In 2008, the IES published an approved test method called IES LM-79-08 that describes the procedures and precautions to follow to measure reproducible electrical and photometric characteristics of Solid-State Lighting (SSL) Products. In this testing method, the term SSL product is used indifferently for a lamp or a lighting product. This approved method recommends the measurement of absolute total luminous flux using an integrating sphere or a goniophotometer.





An integrating sphere is used to characterize lamps in order to obtain the total luminous flux, chromaticity coordinates (x, y), correlated color temperature (CCT) and color rendering index (CRI).



All these parameters are calculated from the spectral power distribution (SPD) of the lamp. The same process is recommended in the IES LM-79-08 test method for the SSL products.

A goniophotometer is mainly used for measuring lighting product luminous intensities in order to generate a photometric file. When testing SSL products, the absolute photometry is mandatory.

Due to the fact that lighting professionals are more familiar with relative photometry method and that the main purposes of relative and absolute photometry are quite different, a

confusion and inadequate usage of photometric reports done according to IES LM-79-08 test method for SSL products.

This paper will focus on absolute photometry of SSL products. We are proposing a new way that will give us reliable photometric results from which we can establish the true performance of Solid-State Lighting Products.

IES LM-79-08 issues

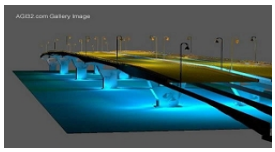
The IES LM-79-08 test method describes the procedures and precautions to follow for measuring reproducible electrical and photometric characteristics of Solid-State Lighting (SSL) Products. The foreword of the IES LM-79-08 test method mentions the reasons why relative photometry cannot be applied to SSL products and why absolute photometry is necessary.

The electronic photometric data file format for relative and absolute photometry is described in the ANSI/IESNA LM-63-02. As per this standard, ‘’Relative photometry consists of the evaluation of the photometric characteristic of a lamp by comparison with the assumed lumen or spectral output of a test lamp. […] Absolute (or direct) photometry consists of the simultaneous comparison of a standard lamp and an unknown light source’’.

Relative photometry

Relative photometry is used for characterizing lighting products with traditional light sources such as incandescent, fluorescent, high intensity discharge or induction lamps. Relative photometry of traditional lighting products is performed with reference ballast to the exception of DC lamps.

Relative photometry produces luminous intensity values which are independent of the exact lumen



output of the test lamp and assumes that the lamp(s) used in the lighting product deliver(s) the initial rated lumen value published by the lamp manufacturer. In this way, two tests of the same lighting product using different lamps of the same type will produce identical results in normal conditions.

Relative photometry method is used for evaluating performance of lighting products, establishing comparison between lighting products and running lighting calculations to predict lighting levels on a task.

Absolute photometry

Absolute photometry method is performed with commercial ballast or driver to the exception of DC lamps.

In absolute photometry, the luminous intensity values represent the actual values produced by the lamp or the lighting product. These values are valid only for specific conditions at a specific time.

Information obtained from absolute photometry is valid only for the lamp or the lighting product tested and cannot be used for any other lamp or lighting product if a representative sampling is not available.

Absolute photometry is mainly used as a mean of quality control to verify intrinsic characteristics of bare lamps or lighting product at a precise moment and in specific conditions. When absolute photometry is used, testing the same lighting product with two similar light sources can produce different results. Because of this, absolute photometry test reports from different laboratories will not necessarily correlate.

In summary, relative and absolute photometry are used to evaluate intrinsic characteristics of lighting products. Relative photometry is used to compare lighting products. Absolute photometry is used as a mean of quality control and for measurement of luminous intensities of a lighting product at a specific time, conditions and location.

In relative photometry, a single test is sufficient to obtain the performances of the tested product used while a good sampling is necessary with absolute photometry. Furthermore, absolute photometry is not based on lamp lumens.

Particularities of absolute photometry

The ANSI/IESNA LM-63-02 standard requires that lamp lumens be marked as -1 in the IES data file when absolute photometry method is used. We should not do efficiency calculation with lamp lumen as a divider in absolute photometry. The functionality of loading absolute photometric files for evaluating products efficiency and run lighting calculations was disabled.

Misinterpretation and inadequate usage of SSL photometry

The scope of the IES LM-79-08 says: “This document describes test methods for individual SSL products, and does not cover the determination of the performance rating of products, in which individual variations among the products should be considered”.

Even with this statement, some lighting professionals are using information from a single photometric test done according to IES LM-79-08 test method to evaluate performances of lighting products and to run lighting calculations.

Furthermore, the IES LM-79-08 test method says in the sampling paragraph of the annex: “Measurement of one sample is insufficient for

rating SSL products and appropriate sampling and averaging of results is required for SSL products." Some lighting professionals want to do with absolute photometry what they used to do with relative photometry. Relative photometry is not adequate for SSL products because we should not separate the lamp from the lighting product according to IES LM-79-08 test method.

Traditionally, the purpose of doing photometric measurement of a lighting product is to determine its light distribution and characteristics in a way that will most adequately describe its performances on a task. In relative photometry, a single test is sufficient to obtain the performance of the lighting product. Some lighting manufacturers tend to perpetuate this practice while a single absolute photometric test is not sufficient to represent a whole series of lighting products.

Today, lighting software allow performing lighting calculations with absolute photometry in exactly the same manner as a relative photometry without knowing if the photometric file used in the calculations is the result of an averaging of different tests from an appropriate sampling.

This practice is a violation of the IES LM-79-08 test method because this test method requires a good sampling. It seems like SSL products are the cowboys in the far west without sheriff.

Sampling Issues

The IES LM-79-08 test method does not define the size of the sampling and leaves this heavy responsibility to other organizations.

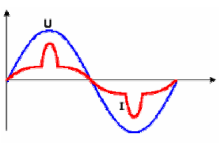
Lighting manufacturers will continue to supply only one sample as long as the number of samples to be tested is not clearly defined by a regulatory lighting authority.

Absolute photometry necessitates a larger sampling to characterize a product. For example, the Institute of Transportation Engineers (ITE) specifies for all its LED product standards that six modules shall be used in Design Qualification Testing. All six modules should be subjected to conditioning. Three of the six modules shall undergo Photometric and Colorimetric Tests and the remaining three modules shall undergo the Electrical Tests.

Furthermore, according to the Institute of Transportation Engineers, Design Qualification Testing shall be performed on new module designs, when a major design change has been implemented on an existing design or after every 5 years that a design is in service.

The same requirements could have been applied to IES LM-79-08 because the light source used on those products has the same behavior.

Total harmonic distortion Issue (THD)



The rate of current harmonic distortion is an electrical parameter which defines the overall distortion of the magnitude of the sine wave and the level of pollution from a power grid.

The higher the rate of harmonic current distortion of a load connected to a power grid, the higher the cost of correcting the signal returned to the network are high.

Some SSL products used electronic drivers. These drivers are non-linear electrical loads. The connection of such loads on a power grid can cause a disturbance if the rate of current harmonic distortion generated is too high.

It is surprising that the IES LM-79-08 test method does not prescribe any requirements on the Total Harmonic Distortion. This omission should be rectified because high rates of harmonic distortion in current create operating losses and especially heating in the electrical equipment, which leads to aging and premature breakage.

SSL product performance

In accordance with Article 9.0 of the IES LM-79-08 test method, the total luminous flux of SSL products should be measured with an integrating sphere or a goniophotometer and the measured lumens are the lumens of the lighting equipment tested and not the lamp lumens since we cannot dissociate the lamp from the lighting product.

Therefore, no calculation of normalization can be performed on the value of lamp lumens since they are unknown. With the IES LM-79-08 test method, the concept of luminous efficacy is associated with the lighting product and not with the lamp. The luminous efficacy is the ratio between the amount of light produced and the total electrical energy consumed by the lighting product.

This performance is expressed in lumens per watt and is used as a figure of merit in the IES LM-79-08 test method. Moreover, the definition of the efficiency of a lighting product loses its meaning since this efficiency is the ratio between the luminous flux leaving the lighting product and the luminous flux emitted by the lamp, the latter being unknown.

The classification system for outdoor luminaires described in the publication TM-15-07 of the IES is designed around the lamp lumens. In this new system, classifications Full Cutoff, Cutoff, Semi- and Non-Cutoff Cutoff are replaced by zonal luminaire lumens and percentages of lamp lumens in predefined zones.

For SSL lighting products, only the zonal lumens can be calculated since the lamp lumens are unknown.

The publication TM-15-07 of the IES should be revised to take into account the particularities of absolute photometry and the characterization of SSL lighting products. We recommend that the calculations of percentages of lumens be established on the luminaire lumens and not on lamp lumens.

Lighting calculations with SSL products absolute photometry

It is appropriate to assign the value of -1 to lamp lumens in absolute photometric files of SSL lighting products to meet the particularities of the method of absolute photometry, to meet the ANSI/IESNA LM-63-02 and also to prevent any calculation of normalization based on lamp lumens.

Software designers of lighting calculations have been very slow to adapt their program to the IES LM-79-08 test method. Meanwhile, lighting professionals edited the photometric file by changing the lamp lumens to be able to perform lighting calculations. The photometric file used in lighting calculations should be secured.

Again, the lighting calculations are sometimes based on a photometric file that is not necessarily the result of a weighted average of tests on a sample of the product, as stipulated in the IES LM-79-08 test method.

Current concerns

Before concluding this article, the technical team of the laboratory Spectralux wishes to share its concerns with the lighting industry in formulating the following three questions:

1. Do we have effective tools to adequately evaluate the performance of SSL lighting products?

2. Do we have measuring instruments to verify and validate the performance of SSL lighting products on job site, when a series of correction factors must be applied to measurements?

3. How the standardizing bodies can adjust themselves to the rapid development of the promising technology of SSL products?

We understand that testing a SSL product is not an easy task due to the fast evolution of that technology and the reliability of components such as electronic drivers, heat sinks, etc.

Conclusion

1. Absolute Photometry

In the past, relative photometry was used to describe the performances of lighting products that work with traditional light sources. Today, the IES LM-79-08 test method requires that absolute photometry be used to characterize SSL products.

2. Size of sampling

According to the IES LM-79-08 test method, a single sample is insufficient to assess the performance of SSL products and a weighted average of the results is necessary.

However, this test method does not define the size of the sampling. For reference, the Institute of Transportation Engineers states that 3 samples are tested electrically and photometrically in all its standards of LEDs traffic lights.

3. Weighted absolute photometry

The concept of weighted absolute photometry proposed in this paper stems from our understanding of the IES LM-79-08 test method.

With a minimum of 3 test samples, lighting laboratories could produce a weighted absolute photometry and a test report in which the uncertainty and the standard deviation would be reported. This standard deviation would determine if the three tests are representative.

The weighted absolute photometry could also be used as a mean of quality control by lighting manufacturers. This approach would enable them to validate the reliability of all components used in their product.

4. *Total harmonic distortion issue*

The rate of current harmonic distortion and the power factor are used as control parameters by the electricity utility companies to protect their network from any form of pollution.

The test method LM-79-08 IES requires the measurement of power factor and does not indicate the rate of current harmonic distortion. The Institute of Transportation Engineers requires a power factor greater than 0.90 and a rate of current harmonic distortion below 20% in all standards for traffic signals and signal LEDs. These two limit values could be used as a guide in new performance standards for electrical products LEDs.

5. *True performance of SSL products*

The test method LM-79-08 IES uses the luminous efficiency of lighting products tested as a figure of merit.

The luminous efficacy (lumens / watt) of a lighting product is not necessarily a good indicator of its performance in a given application. Several lighting products may have the same luminous efficiency while having different performance for a given lighting application. The light distribution of a product on a task makes all the difference.
A good lighting device is a device that provides at all times acceptable level of lighting, security,

uniformity and an excellent visual comfort, all at lower power consumption.

We are proposing to characterize the SSL products by using the notion of lux per watt or candela per square meter per watt. This performance is obtained by dividing the average illuminance or the average luminance by the total electricity consumption of lighting products used in lighting calculations.

This new technically solid performance criterion would be an addition to lighting requirements already identified by the IES for a given application and would give the true performance of lighting products in an application.

6. *Security of electronic photometric data file*
The structure of the electronic photometric file described in ANSI / IESNA LM-63-02 provides no security. Photometric files in IES format can be easily changed.

It is probably time for a thorough revision of the ANSI / IESNA LM-63-02 on the electronic transfer of photometric files to secure data and prevent any changes. Techniques for encryption and decryption could be used in this sense.

7. *Standardization*

The challenge seems to be important for the regulatory organizations and for the manufacturers of lighting equipment which must master the new technology of SSL products in all its complexity.

It is therefore urgent to act quickly to prepare, develop and publish new standards that would adequately assess the performance of SSL products. Strong requirements and technical criteria should be given in these new standards.

The collaboration of all parties involved in the lighting industry is therefore necessary to bridge this gap.

The rapidly evolving technology of SSL products is part of a real and promising process of sustainable development and could provide promising solutions to many social, ecological, economic and environmental problems.

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