New method for characterization of retroreflective materials

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Abstract: The present article aims to propose a new method of analyzing the properties of retroreflective materials using a goniophotometer. The aim is to establish a higher resolution test method with a wide range of viewing angles, taking into account a three-dimensional analysis of the retroreflection of the tested material. The validation was performed by collecting data from specimens collected from materials used in safety clothing and road signs. The approach showed that the results obtained by the proposed method are comparable to the results obtained by the normative protocols, representing an evolution for the metrology of these materials.

Keywords: Assay, Retroreflexion, Goniophotometry, Comparison.

1. INTRODUCTION

The determination of properties of the retroreflective materials has been benefiting from the evolution of the positional photometric technologies, with lower uncertainty and automation for positioning, which reduces times and costs. Although this fact is relevant in the various methods applied, practices that require a considerable amount of time to perform tasks and insufficient amount of data are still perceptible. The evolution of metrology has brought new possibilities to minimize uncertainty, which allows a continuous work improvement. Thus, the method presented here aims to broaden the range of data collected, allowing a broader analysis of retroreflective material and, at the same time, increase the accuracy. In this way, a more secure definition of the conformity of these products is possible. Another objective is increasing productivity with the method, which makes it possible to reduce the number of professionals required to perform the test. This generates cost reduction, time reduction and greater dynamism in laboratory operations.

1.1 Definition of Retroreflection

As defined by CIE 33.7 of 2001, retroreflection is the superficial phenomenon of reflection, in which the reflected rays are returned preferentially in directions close to the opposite direction of the incident rays and this property is maintained over wide variations in the direction of the incident rays. Thus, the retroreflетance is the proportion of the radiating flux (or luminous flux) emerging relative to the incident flow, within the restriction angle of the geometric conditions of incidence and reflection. (CIE 33.7, 2001), as can be verified in figure 1.

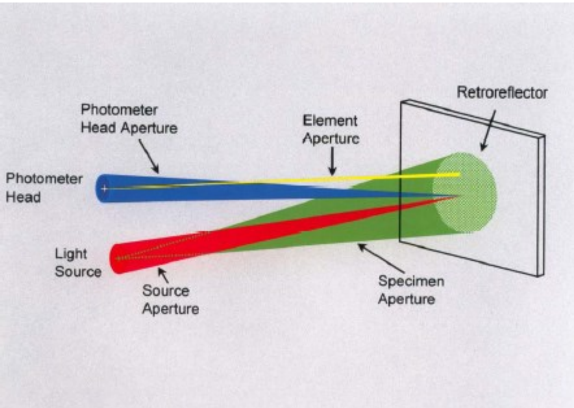

Figure 1 – Illustration of aperture angles for Retroreflection (CIE 54.2 ,2001).

Retrorefletor is a material with a surface or device that exhibits retroreflection. (CIE 54.2, 2001). Retroreflective material is a material that has a thin continuous layer of small retroreflective elements on or very near to its surface (e.g., retroreflective sheeting, beaded paint, highway sign surfaces, or pavement striping).

1.2 Definition of Goniophotometry

The goniophotometers are equipments used for measurements of the optical characteristics of luminous bodies. The name derives from traditional goniometers that are single-purpose instruments to angular measurements. In addition to the photometric component contained in the name, it is added to the significance of angular measurements of the optical characteristics of luminous bodies.

The goniometers allows to determine primarily the luminous flux (given in lumens), and the light distribution graph of the emitted light. The item to be evaluated can be a luminaire, a lamp or other light emitting devices (IESNA-LM-79, 2008). With this equipment, all the optical characteristics of the products can be evaluated accordance to the angular measurements of the light emitting spectrum of the luminous bodies (CIE 121, 1996). There are varied types of goniophotometers constructions, so it is necessary to use classifications. Among the goniophotometers, there are those of type C. These are ideal for measurements where the object to be measured is stationary. (Iesna-LM-79, 2008). In the near field goniofotometry the luminance of a surface in all directions is measured to construct the profile of distribution of intensities as if all the light were emitted from a single central point. In fact, the luminance measured in the direction of the illuminator is affected by the shade of the illuminator body. However, as the illuminator shadow dimensions are relatively smaller than the reflecting surface, this influence is diluted by the fact that the sensor measurement field (image observed by the ccd) can be accounted for within the uncertainty of the luminance measurement. See a typical arrangement in Figure 2.

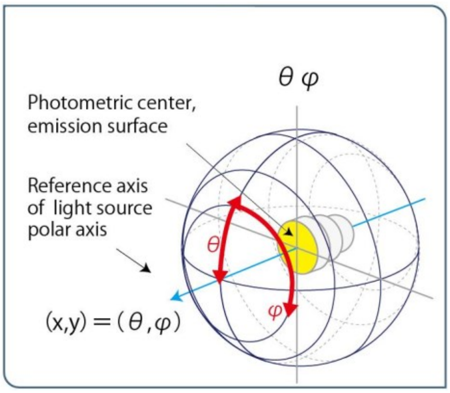

Figure 2 – Graphical representation of the Goniophotometers type C, in the center is positioned the luminous body to be measured, and on the axes in red are represented the axis of the sensor's offset. The illuminator was held fixed and aligned to the normal surface of the reflector. (Located in : https://www.otsukael.jp/upload/files/GP%281%29.jpg Accessed on: ago 2017).

For measurements of intensity distributions in a goniometer type C, the object to be measured is positioned in the geometric center of the goniometer. In one of the arms of the goniometer, a CCD camera (the photometer) is positioned and this accompanies the movement on the imaginary spherical surface by which the movement of the sensor occurs. the radius of this sphere is fixed, varying only the angle of the camera. (TECHNOTEAM, 2015).

2. TEST METHOD

In this method of retroreflectance proposed, the equipment was used according to the traditional method described in the norms ASTM E808-01 (2016), ASTM E809-08 (2013) and ASTM E810-03 (2013), which can be summarized as: Goniometer; Photometer; Light source; Surface of the test body and dark photometric room. The validity of the measurements was guaranteed by the verification of the minimum instrumentation requirements laid down by the above mentioned standards, namely:

- Goniometer: Minimum resolution of 1° for angular step;
- Photometer Receiver: 1931 CIE standard Photopic Observer, insensitive to light

polarization, linearity of photometric and stable scale;

- From the light Source: correlated color temperature (CCT) of 2856 K, non-polarizing light and proportional distance of the test body;
- From the surface of the proof body: variation of Iluminance below 61% and uniformity above 65%;
- The proof body: dimensions proportionate to the distance of the light source;
- The environment: A level of background light below 5% to the incident;

Some adjustments were needed to meet the requirements. With regard to the goniometer, photometer receiver, body of evidence and body of proof, all requirements were met in function to the infrastructure already existing in the laboratory. In the light source item, a LED flashlight with emission spectrum in the 5000k range was used with application of filters to reach a CCT of 2856 K ± 20k determined by ASTM E809-08 (2013). This adaptation can be observed in figure 3.

Figure 3-Measuring assembly diagram of the CCT of the light source. In the right corner the filters used for adjusting the CCT of the light source (flashlight)(IPT, 2017).

After adjusting the color temperature in the light projector, the goniometer was used to characterize the light source as its emission curve. For this, the projector of light was positioned in the geometric center of the goniometer and the measurements were carried out to generate the table of distribution of the emission intensity of the projector for each given angle.

Finally, the support assemblies were carried out for the positioning of the body of evidence and the source of light, seeking to always maintain proportionality to the arrangement of the ASTM E810 procedure, as shown in figure 4.

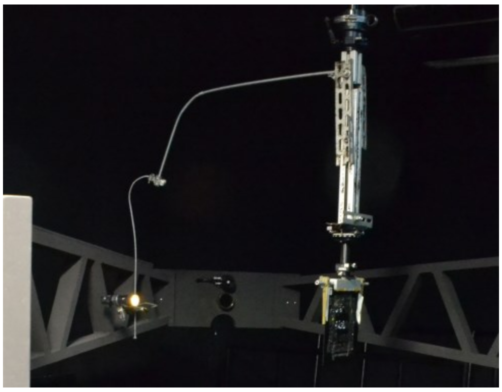

Figure 4 – Mounting diagram for measurements of the retroreflective characteristics. On the right side we have the surface for placement of the body of evidence and, on the left, the light source. (IPT, 2017).

In this case it was positioned a plate with retroreflector (square body of dimensions of 44mmX44mm) in the geometrical center of the Goniofotômetro and perpendicularly to this axis, the projector of light was positioned to a distance of 70cm, in the normal direction of the reflecting surface. The measurements were carried out seeking to determine the distribution of light intensities reflected by the retroreflective material, maintaining the position of the axis of the incident light. The norms demand the determination of the retrorefletance coefficient of these subjects in Candelas(CD) divides by Lux times meter squared (CD/lux. m²). The distribution of intensities determined by the goniophotometer allows to calculate the illuminance (in Lux) to the observer in the sensor direction. The source intensity (on CD) is determined by a photometer positioned on the sample plane and the sample reflection area (in m²) is measured directly.

3. RESULTS

In figure 5 a three-dimensional representation of the data obtained may be verified.

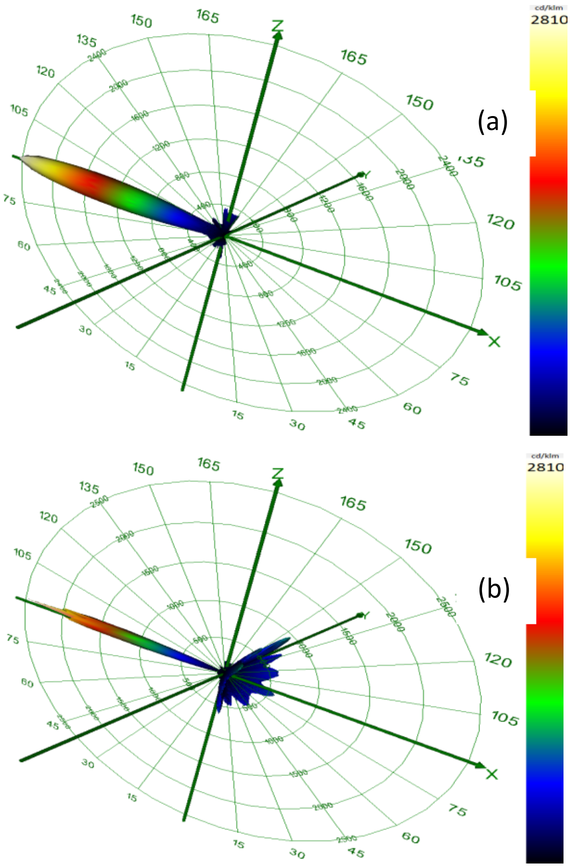

Figure 5 – Distribution of luminous intensity obtained from (a) projector and (b) Retroreflective material (IPT, 2017).

In the Figure 5b, "leakage" of residual light is observed for the posterior portion of the specimen, which can be resolved placing the test bodie on a larger mounting bracket.

Measured in the goniophotometer, the data was analyzed in order to understand and define the optical characteristics of the retroreflective material. It was also sought, as in the norms, to determine the coefficient of retrorefletance in the various angles that the distribution of intensities allows. This implies an analysis capability with a higher resolution and higher breadth than determined by the standards, because it is not restricted to just a few angles but it allows to evaluate the coefficient of retrorefletance for all angles of the frontal hemisphere of the sample.

It is estimated that the data has an uncertainty of the order of 3%, compatible with the data obtained with the conventional method (Goniophotometry in a photometric tunnel). However, simulating a vibration in the bracket, it was observed that this uncertainty could reach 7%. Therefore, a critical portion of this method is the rigidity of the support that maintains the projector at distance and fixed position relative to the tested body. This aspect should receive more attention in the experimental assembly.

4. CONCLUSIONS

The method proved to be practical, allowed less time spent on both mounting and data acquisition and allowed a better angular resolution for measurements. The norms and documents that specify requirements for retrorefletive materials follow parameters limited by a lesser amount of angles. In this case, the angles and the number of information were shown more comprehensive for analyses. It can additionally generate three-dimensional graphs, which provides very rich and precise information for the characterisation of the retoreflective materials, which provides better conditions for verification of the requirements laid down in the DENATRAN resolutions.

5. REFERENCES

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