Photometric measurements of LED luminaires: which goniophotometer

The American norm LM-79 states that the most suitable instruments for measuring photometries of LED luminaires are:

- mirror goniophotometers (Fig.1)
- rotating photocell goniophotometers where the photocell rotates around the luminaire (Fig.2)

whose common feature is that of keeping the lighting device in its normal function position with respect to gravity during measurement.

Modern goniophotometer technology however proposes other types of machinery such as luminaire rotation goniophotometers where the luminaire rotates in space around its own luminous barycenter (Fig.3)

All these types of machinery, and the laboratories where they are installed, are nowadays equipped with:

- current, voltage and power supply control systems capable of guaranteeing minimum voltage variation percentages of less than 0.1%
- systems for high precision evaluation of angular positions (over 1/10 of a degree)
- systems able to guarantee reduced measurement time, a few dozen minutes, while still maintaining a high level of precision
- sophisticated temperature control systems to maintain a constant temperature of 25°+/- 1°

to guarantee an accuracy of measurement that was unheard of only a few years ago.

The greatest difference between the various machines is therefore how the luminaire is managed in space: mirror and rotating photocell goniophotometers (Fig.1+2) keep the luminaire in horizontal functioning position, as opposed to luminaire rotation goniophotometers where the luminaire rotates in space outside the horizontal plane.

This is the greatest criticism levelled at luminaire rotation goniophotometers: since they are unable to manage the luminaire in its normal functioning position, it is therefore impossible to maintain the

Fig.1 – Mirror goniophotometer

Fig.2 – Rotating photocell goniophotometer

Fig.3 – Luminaire rotation Goniophotometer

thermal function state of the LED which, being extremely sensitive to variations in temperature, cannot ensure constant luminous emission (flow) throughout measurement, thus invalidating the calculation itself.

OxyTech, in mutual agreement with several associations, including the Politecnico of Milan – Industrial Design Faculty, and a number of manufacturers, has carried out various comparative trials to verify whether sufficient differences really exist to justify the affirmation that the mirror goniophotometer is capable of greater precision than the luminaire rotation model.

The numerous trials carried out do not seem to justify this finding, at least for the luminaires under scrutiny.
This table summarizes the results of the trials carried out on a LED street lighting luminaire with heat sink.

Measurement by	Goniophotometer Type	Flux [lm]	Max.Int. [cd/klm]		
Manufacturer	luminaire rotation (T2 OxyTech)	5168	643		
Third party laboratory	mirror (GO2000 LMT)	5196	642		
Politecnico MI	mirror (T4 OxyTech)	5157	643		
OxyTech	luminaire rotation (T2 OxyTech)	5214	650	Continuous measurement without machine stop in each measurement position	
OxyTech	luminaire rotation (T2 OxyTech)	5210	647	Step measurement with machine stop in each position evaluating at least 3 values for each position	

All tests were carried out controlling the stability of the flux emitted in the initial phase and verifying that the divergence in the measured values, referring to the same point, was no greater than 1% over time. Stability control was then repeated at the end of each measurement for more than one minute, comparing the read values with the initial values and verifying whether the divergence was greater also here than the 1% foreseen, if so the trial was to be annulled.

Furthermore, attempts were made to verify whether the length of the trial with a luminaire rotation goniophotometer could actually influence the trial results; therefore, the luminaire was measured in 2 different ways with notably different trial lengths:

- continuous, without stopping machine movement during measurement, taking a total time of around 40 minutes
- step, which foresees machine stop in each measurement position and subsequent measurement of at least 2 values per point, a method that requires on average 3 times the length of time as the first.

The results summary table shows that there are no appreciable differences between the various measurements, illustrating that:

- the divergence between the maximum intensity values is 1.2% (difference between minimum and maximum value)
- the divergence between total flux emission values is 1.1% (also here considering the difference between minimum and maximum value).

These percentage differences easily fall within the acceptability limits of comparative trials on the same luminaire; the polar curves are also visibly comparable.
At this point, attempts were made to understand what can really influence the luminous emission of a LED luminaire by carrying out trials on a number of systems without heat sinks, finding that the rotation of the LED in space leads to notable differences in luminous emission.

Is there a theoretical justification for these results ?
In our opinion, there is: the LED is an element that is sensitive to variations in temperature if considered without heat sink but it becomes **insensitive** if equipped with a well-proportioned heat sink that is able to maintain the working temperature at the junction constant after reaching thermal stability.
This seems to be the real condition for discriminating between good and poor quality LED lighting devices and the luminaire rotation goniophotometer allows this quality to be evaluated since it places the luminaire under “stress” in the worst functioning conditions.

Many LED luminaires, such as floodlights, do not have a unique, well-defined orientation in space in their practical installation: it may therefore happen that, when measuring the luminaire with a mirror goniophotometer, a certain flux value would be obtained if the horizontal glass floodlight were mounted downwards. This value would then be unfulfilled in the practical installation if the floodlight were mounted vertically: in this way it would be impossible to guarantee the illuminance values forecast in the simulation calculations.

That is to say, the luminaire rotation goniophotometer, equipped with sophisticated stability control systems, would be better able to "evaluate" the quality of a LED luminaire, intended as a combination of a LED source and relative heat sink, and guarantee a superior quality product.

We therefore retain that it is opportune and necessary to increase the number of tests to verify and confirm what is described above, inviting other laboratories to carry out repeat tests on the same luminaires to obtain a wider range of findings.

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