

## **Further Consideration of Obtrusive Light**

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IESNA publication TM11, “Light Trespass: Research, Results and Recommendations,” has evaluated factors that influence whether an outdoor luminaire is obtrusive and objectionable.<sup>1</sup> The research was conducted for situations where a light source of variable size and intensity was positioned fairly close to observers.<sup>2</sup> It was concluded that the degree to which a luminaire is objectionable can be evaluated by the “eye illuminance” that it produces. Eye illuminance is the illuminance occurring at the point of observation on a plane perpendicular to the direct line of sight to the luminaire. It may also be related to the level of disability glare that the luminaire produces, although this has not been proven. TM11 introduced the concept of environmental lighting zones to North America, and recommended limits on eye illuminance were proposed for the different zones.

All research conducted in the preparation of TM11 used relatively small distances between the observer and the test luminaire, with maximum distance of 49 ft.

The recommendations of TM11 have been incorporated into IESNA publication RP33, and they have been successfully applied in many actual lighting designs.<sup>3</sup>

### **Further Considerations**

TM11 appears to cover adequately the situation to which it was intended to apply: The objectionable nature of light sources at a relatively close distance. However, it did not attempt to address a further form of obtrusive light that may be referred to as “nuisance glare.” This effect may be caused by distant light sources; sources that may or may not produce any significant level of either discomfort or disability glare. Nuisance glare refers to the objectionable nature of a source that constitutes a bright point of light where darkness would be preferred. Such light is environmentally undesirable and normally will result from inadequate optical control of the distant luminaire.

When a light source is at a considerable distance from the observer, its size becomes of low significance. Essentially, the luminaire becomes observed as a point source. For example, research has shown that the visibility of a traffic signal, viewed under daylight conditions, is determined by its intensity rather than its luminance for observation distances greater than approximately 200ft.<sup>4</sup>

Allard’s law governs the visual range of bright sources viewed at night. This law states that the distance at which a signal source is visible is determined by the *intensity* of the source and the atmospheric transmittance (when the luminance of the source is large in comparison to its background).<sup>5</sup>

For a distant source, therefore, it is the source intensity that governs its appearance. To control light trespass fully it is thus necessary to place limitations on source intensity, as well as the eye illuminance values in table 1 of TM11. In this way, a complete framework will be provided for the design of outdoor lighting that applies to sources at any distance.

### **Luminaire Intensity (Candlepower)**

In considering such an approach to limit nuisance glare, it is highly convenient that the luminous intensity, or candlepower, of a luminaire is provided directly by a photometric test report. As photometric data files in the standard IESNA format contain intensity values over a fine angular web, determining the luminaire intensity in directions of interest is a simple design step.

Other organizations have adopted luminaire intensity as part of their framework to control light trespass. The Commission Internationale de l' Eclairage, CIE, provides limiting intensity values.<sup>6</sup> The Illuminating Engineering Society of Australia and New Zealand, IESANZ, similarly provides recommended intensity limitations.

The recommendations of the CIE obtrusive light report related to luminaire intensity are as follows:

#### **Maximum values for intensity of luminaires in designated directions**

<b>Light Technical Parameter</b>	<b>Application Conditions</b>	<b>Environmental Zones</b>			
		<b>E 1</b>	<b>E 2</b>	<b>E 3</b>	<b>E 4</b>
Luminous intensity emitted by luminaires (I)	<i>Pre-curfew:</i> Limits apply to each luminaire in directions where views of bright surfaces of luminaires are likely to be troublesome to residents, from positions where such views are likely to be maintained, ie not where momentary or short-term viewing is involved.	<b>2 500 cd</b>	<b>7 500 cd</b>	<b>10 000 cd</b>	<b>25 000 cd</b>
	<i>Post-curfew hours:</i>	<b>0 cd*</b>	<b>500 cd</b>	<b>1 000 cd</b>	<b>2 500 cd</b>

\* If the luminaire is for public (road) lighting then this value may be up to 500 cd

### **Intensity (Candlepower) Measurement**

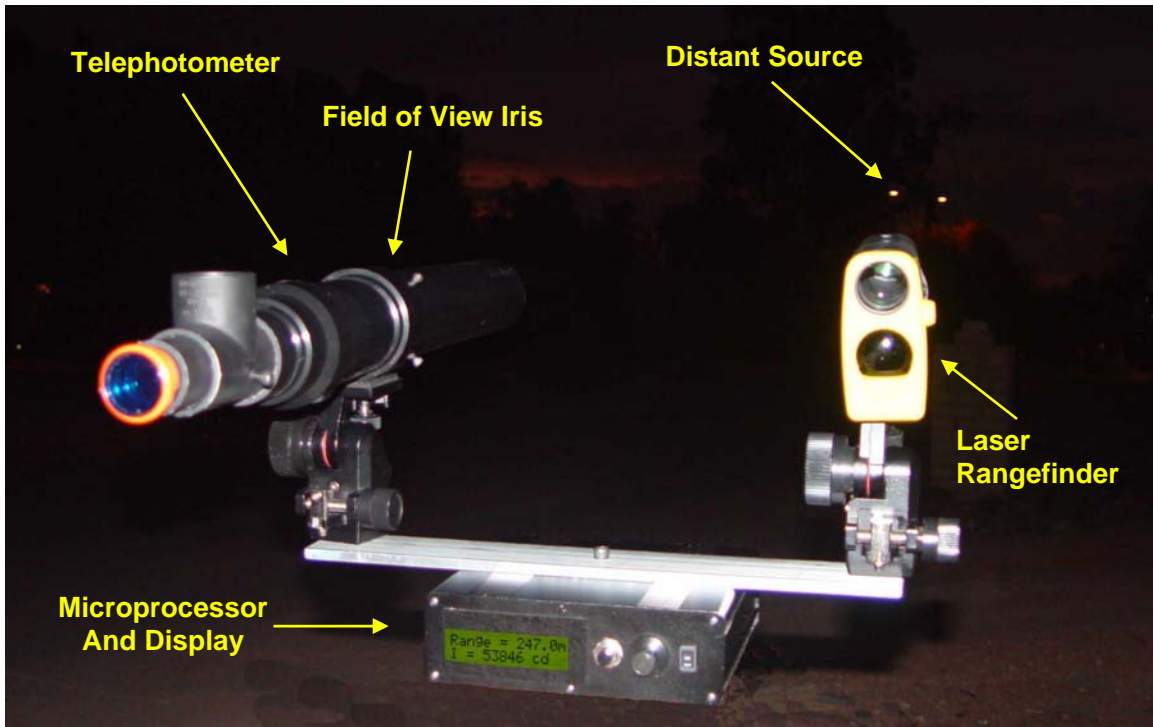
To be a feasible quantity for controlling light trespass, it is highly desirable to be able to conveniently measure the quantity under field conditions. Eye illuminance fulfills this requirement, as it may be measured using a modified illuminance meter.

Intensity cannot be measured directly. It may, however, be indirectly measured. For the intensity directed from a luminaire towards an observer:

$$\text{Intensity} = \text{Eye Illuminance} \times \text{Distance}^2 \quad \dots\dots 1$$

Illuminance in lux, distance in meters  
Illuminance in footcandles, distance in feet

To address this requirement, a light trespass metering system has been developed, figure 1, that provides the ability to determine the intensity of a distance source. A telephotometer is used to sight the luminaire of interest, and an adjustable internal iris then is reduced in diameter to screen out other luminaires. The photo detector and electronics are calibrated in terms of eye illuminance and this value is fed to a microprocessor. A coupled laser rangefinder measures the distance to the luminaire, likewise feeding its output to the microprocessor. The microprocessor computes intensity per equation 1 above, which is displayed on the digital rangefinder.



**Figure 1. Light Trespass Meter**  
**Photo: Courtesy Lighting Sciences Inc.**

A measurement capability such as described can be used to check compliance of a luminaire to lighting codes that incorporate intensity and/or eye illuminance as a design criterion.

## **Disability Glare**

As an interesting by-note, there is a further advantage of considering intensity as a means of limiting obtrusive light. Considering disability glare, it is known to be affected by three factors:

Luminaire intensity  
Distance from observer to luminaire  
Angle between line of sight and direction of view to luminaire

In matters of light trespass, it is common to consider the worst viewing angle, which is when the observer has a line of sight directly towards the luminaire. For such cases, disability glare will be governed only by intensity and distance.

In many situations, distance is not fixed, as the luminaire may be viewed by an observer over a wide range of distances.

Thus for a luminaire viewed with a direct line of sight and over a range of possible distances, the governing variable is luminous intensity. For this generalized situation, therefore, specifications based on intensity also indirectly take into account disability glare.

## **Conclusion**

It is suggested that the Obtrusive Light subcommittee of the IESNA Roadway Lighting committee consider the incorporation of luminaire intensity into the recommendations of TM11 as a means of controlling nuisance glare in outdoor lighting design.

## **Appendix**

### **Comments Regarding the Model Lighting Ordinance**

IESNA and IDA, the International Dark-Sky Association, are in the process of developing a model lighting ordinance, MLO. The MLO is anticipated to incorporate an advanced luminaire classification system that is based on the lumen output in various specified angular zones. This will provide a worthwhile method for limiting lumens cast in undesirable angular ranges. While this is a laudable step, it should be recognized that this would not necessarily provide complete control of lighting effects related to glare in its various forms.

For example, if a zonal lumen output specification is applied to the angular range from 80 to 90 degrees vertical, the total luminous flux in that zone will be limited, as is desirable. It is quite possible, however, that unacceptably high intensities may occur in this zone over a certain range of horizontal angles, while low intensities may be emitted at other horizontal angles. The net result can be the production of glare, including nuisance glare,

yet the lumen output in the various broad angular ranges may meet the requirement of the MLO.

For example, a roadway luminaire may meet a lumen output limitation in the 80 to 90 degree vertical angle zone but may have very high intensities at lateral angles in this zone at and close to the main beam, where optical control problems are usually the greatest. This may be very undesirable and may be a source of obtrusive light, yet may not cause the lumen output in the entire angular zone to exceed a specified limit.

It is suggested that luminaire intensity be added as a consideration in the applying of the MLO. That is, the broad classification system based on zonal lumen outputs can be expanded to also incorporate maximum intensity limitations as a means of controlling glare effects. However, as in the case of CIE 150, the intensity specifications may be application related: They may apply only to directions of significance for the particular lighting design, rather than being broadly restrictive on the entire luminaire photometric distribution.

An alternative possibility exists: rather than incorporate intensity into the application of the MLO, luminance, or the intensity per unit area of the luminaire, could be used. The author considers this to be highly problematic. Firstly, luminance is a parameter that only affects *discomfort* glare. On the other hand, intensity is the significant variable for spill light, disability glare, and as has been reasoned above, nuisance glare. In all probability, if intensity limitations are specified, then the problem of disability glare should be minimized or eliminated. *This is likely to provide the needed control of discomfort glare also*, for the two go hand-in-hand. In other words, luminance control is unnecessary if intensity is already properly controlled.

Secondly, which luminance quantity would be specified? Possibilities are:

Luminaire average luminance. This is obtained by dividing the intensity at the angle of interest by the projected area. Which projected area should be used? If the projected area of the entire luminaire is applied, this will not be visually meaningful as some parts of that area may not be luminous.

Average luminance of the flashed portion of the luminaire. What portion of the luminaire is considered to be flashed? At what level of “point luminance” is the luminance high enough to justify inclusion? Even if a solution to this conundrum were to be found, the flashed area will change for every luminaire, and will even do so for the same luminaire with different lamp types.

Maximum luminaire luminance. Notwithstanding that we may query whether this quantity is visually meaningful, it would still be necessary to specify an area: i.e. The maximum luminance *over what measurement area*? The luminance may be several million candelas per square meter if the defined aperture is small and an arc tube is visible, or it may be only a few thousand cd/sq m if the defined area is large and includes lower luminance portions of the luminaire.

The author considers these problems insoluble, and recalls with dismay the failed efforts in the 1970's by the IESNA RQQ committee, which he chaired at the time, to define adequately the luminance of a coffer used in interior lighting systems. The failure was due to the types of considerations described above and the inability to find a realistic and usable solution.<sup>7</sup>

In any case, a fundamental quantity must be measurable, certainly in the laboratory, or it is of no value in a code. Preferably it should be measurable also in the field. A practical method for measuring luminance is effectively impossible to develop given the variables involved just in defining what is meant by luminance, even before considering how such photometric measurements could be made.

These evaluations further emphasize the benefits of a system of specification based on *intensity*, with its inherent benefits of being simple, understandable, and, most of all, meaningful.

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