

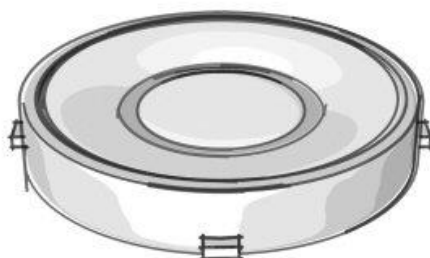
# Zhaga Interface Specification

Book 5

Edition 1.2

April 2014

**Socketable LED Light Engine with Separate  
Electronic Control Gear**



## Zhaga Interface Specification Book 5

### Summary (informative)

#### Background

The Zhaga Consortium is a worldwide organization that aims to standardize LED light engines.

The Zhaga Interface Specification consists of a series of Books, which have been approved by the general assembly of the Zhaga Consortium. Each Book defines a LED light engine by means of its mechanical, photometric, electrical, thermal, and control interfaces to a luminaire. This makes the LED light engines interchangeable in the sense that is easy to replace one LED light engine with another, even if they have been made by different manufacturers.

The Zhaga Interface Specification distinguishes between four kinds of LED light engines, namely:

- socketable with integrated electronic control gear.
- socketable with separate electronic control gear.
- non-socketable with Integrated electronic control gear.
- non-socketable with Separate electronic control gear.

#### Contents

This Book 5 of the Zhaga Interface Specification defines a socketable LED light engine with remote control gear. It has a round cylindrical shape with maximum dimensions of 70 mm diameter and 21 mm height with defined optical accessory widths of up to 180 mm and heights up to 180 mm. It has typical light emitting surface diameters ranging from 13.5 mm to 26 mm.

This Book should be read together with Book 1 of the Zhaga Interface Specification.

#### Intended Use

Book 5 LLEs are intended to be installed and replaced by professionals and non-professionals.

The light engine can be locked into a luminaire by means of a twisting motion. Mechanical fit keying is present to ensure that the luminaire aligns correctly for electrical connection regions where optionally fitted.

The light output is essentially lambertian, which enables the luminaire optics to shape the light distribution to the needs of the application.

The light engine is primarily intended for use in LED down-lighting luminaires or spot luminaires.



# **Zhaga Interface Specification**

## **Book 5: Socketable LED Light Engine with Separate Electronic Control Gear**

**Edition 1.2**

**April 2014**



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# 1 General

## 1.1 Scope (informative)

The System Description Zhaga defines a set of LED Light Engines—light sources for general lighting that are based on solid state technology. Different types of LED Light Engines are defined in different Books of the System Description Zhaga. This Book 5 defines the interfaces between a “Socketable spot LED Light Engine with separate Electronic Control Gear” and a Luminaire.

## 1.2 Main features (informative)

A socketable spot LED Light Engine includes at least one LED Module intended to be inserted and twisted in a clockwise motion to engage with a Luminaire by an OEM Luminaire manufacturer. The light output of the LED module in this book has 2 varieties (1) essentially Lambertian and (2) manufacturer specified beam angle (FWHM) in degrees found in section 4. This document defines the complete LED light engine (LED module and Remote Electronic Control Gear):

- A set of LLE with mechanical, thermal and photometric interfaces to be used in a suitable Luminaire.
- The mechanical outlines and the electrical interface to mains of the Separate Electronic Control Gear necessary to operate the individual LED Module
- A Luminaire that provides the appropriate environment for the LED Light Engine to operate within the specifications set forth within this document.
- A marking scheme for LED Light Engines as well as for Luminaires that allows users to select LED Light Engines that can be operated safely and satisfactorily in the corresponding Luminaire.
- Multiple Test procedures and setups to define and document mechanical, photometric, thermal and electrical to ensure interchangeability between different LED Light Engines used in the same Luminaire.

## 1.3 Conformance and References

### 1.3.1 Conformance

Refer to Section 1.3.1 of Book 1 for definition and description of Zhaga conformance.

### 1.3.2 Normative references

In addition to the provisions in this Book 5 of the System Description Zhaga, product implementations shall also conform to the provisions in the System Overview as well as the relevant parts<sup>1</sup> of the International Standards listed below. For undated references, the applicable revision is the one most recently published at the release date of this Book 5, of the System Description Zhaga.

[ANSI C78.377]	American National Standard for electric lamps—Specifications for the Chromaticity of Solid State Lighting Products, ANSI NEMA ANSLG C78.377.
[IEC 60598]	Luminaires—Part 1: General requirements and tests, IEC 60598-1.
[IEC 61347-1]	Lamp controlgear - Part 1: General and safety requirements: IEC 61347-1
[IEC 61347-2-13]	Lamp controlgear - Part 2-13: Particular requirements for d.c. and a.c. supplied electronic controlgear for LED modules: IEC 61347-2-13
[IEC 62031]	LED modules for general lighting—Safety specifications, IEC 62031.
[IEC 62384]	DC or AC supplied electronic control gear for LED modules - Performance requirements
[IEC /PAS 62717]	PAS LED modules for general lighting—performance requirements, IEC / PAS 62717.

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<sup>1</sup>As referenced in the subsequent Sections of this document.

[ISO 262] ISO general purpose metric screw threads—Selected sizes for screws, bolts and nuts, ISO 262

In addition to the measurement techniques defined in this document, measurement techniques used to characterize product implementations should be verified against appropriate provisions in the International Standards listed below. For undated references, the applicable revision is the one most recently published at the release date of this Book.

[CIE 13.3] Method of measuring and specifying color rendering properties of light sources, CIE 13.3.

[CIE 52] Calculations for interior lighting – Applied Method, CIE 52

[IEC/TR 61341] Method of measurement of center beam intensity and beam angle(s) of reflector lamps, IEC/TR 61341.

[IES LM-79-08] IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products, IES LM-79-08.

[ISO 17025] General requirements for the competence of testing and calibration laboratories, ISO / IES 17025

[EN 13032-2] Light and lighting - Measurement and presentation of photometric data of lamps and luminaires - Part 2: Presentation of data for indoor and outdoor work places

[UL 1598] Safety of Luminaires

## 1.4 Bibliography

The following references provide additional information that may be relevant to the provisions in this Book 5 of the System Description Zhaga.

[CIE 84] The measurement of luminous flux, CIE 84.

[CIE 121] The photometry and goniophotometry of Luminaires, CIE 121.

[CIE 177] Color rendering of white LED light sources, CIE 177.

[IEC 60061-d] Designation of Lamp Caps and Holders, IEC 60061 standard sheet 7007-1.

[ISO 128], [ISO 128-x] Technical Drawings—General principles of presentation—Part *x*, ISO 128-*x* (all parts).

[ASTM D5470] Standard Test Method for Thermal Transmission Properties of Thermally Conductive Electrical Insulation Materials - ASTM D5470

## 1.5 Terms and Definitions

For all Terms and Definitions, reference Book 1 Section 1.4 for common definitions. See below for additional terms and definitions which are not defined in Book 1.

**Electrical Interconnect Zone** Area within the holder which defines the region where a connector may be placed for electrical connection to the ECG and the module.

**Initial <parameter>** value of <parameter> at the moment of purchase or as soon after as possible (0h value), without any preconditioning. In case any preconditioning has been made before the measurement, this has to be marked explicitly together with the measured value.

**Plug** Part of an electrical connection that is attached to wires.

Receptacle	Part of electrical connection that is usually mounted to a rigid structure like the LED module.
Socketable	A new term indicating the ability of a LLE to be mechanically inserted into a holder or socket.
Thermal Test Engine (TTE)	A device that is used to determine the thermal properties of a Luminaire. A Thermal Test Engine is also used for compliance verification with respect to the thermal properties of the Luminaire.
Luminous Flux	Quantity derived from radiant flux by evaluating the radiation according to its action upon the CIE standard photometric observer
Type	LED Light Engine, representative of the production
Type test	Conformity test on one or more LED Light Engines, representative of the production

## 1.6 Acronyms

For all Acronyms, reference Book 1 Section 1.5 for common usage. See below for additional terms and which are not defined in Book 1.

CIE	commission internationale de l'éclairage
EL	essentially lambertian
IEC	international electrotechnical commission
ISO	international organization for standardization
NMI	national metrology institute
RthTF-Spot	thermal resistance test fixture for LLE
SPD	spectral power distribution
TTE-Book 5	thermal test engine for LLE
TPTF-Book 5	thermal power test fixture for LLE

## 1.7 Symbols

For all Symbols, reference Book 1 Section 1.6 for common usage. See below for additional terms and which are not defined in Book 1.

U	Luminance uniformity parameter
$L_i$	Average Luminance in Area i (unit: $W/m^2sr$ )
N	Number of Luminaire camera pixels within LES
$N_{bright}$	Number of pixels that are brighter than a reference value
$P_{thCH}$	electrical power applied to the correction heater of TPTF (unit: W)
$P_{th,max}$	Maximum thermal power generated by LED Module (unit: W)
$P_{th,rear,max}$	Maximum thermal power generated by LED Module at its Thermal Interface Surface (unit: W)
$R_{th}$	Thermal resistance of the Luminaire (unit: K/W)

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$R_{sp,max}$	Maximum thermal spreading resistance (unit: K/W).
$R_{th,rear}$	Thermal resistance at Thermal Interface Surface for power generated by either LED Module or TTE (unit: K/W)
$R_{th,rear,max}$	Maximum thermal resistance of Luminaire heat sink that is required by the LED Module (unit: K/W)
$t_{r,TTE}$	Temperature at reference location Thermal Test Engine (unit: °C)
$t_{r,mod}$	Temperature at reference location of LED Module (unit: °C)
$V_{HFS,TTE}$	Heat flux sensor voltage for the thermal test engine.
$V_{HFS,LLE}$	Heat flux sensor voltage for the LLE.

## 1.8 Conventions

For all conventions including Cross References, Informative Text, Terms in Capitals and Units, please reference Zhaga Book 1 Section 1.7.

## 2 System Overview (informative)

The System Description Zhaga consists of a series of Books, which define the interfaces between various kinds of LED Light Engines (LLE) and the Luminaires in which these LED Light engines can be applied. An LED Light Engine is a light that complies with the provisions in one or more of the Books in the System Description Zhaga. An LED Light Engine consists of one or more LED Modules, associated Electronic Control Gear, and additional mechanical and/or optical components. In the context of the System Description Zhaga, a Luminaire is a lighting fixture, which is designed to operate with an LED Light Engine. Interchangeability of an LED Light Engine and a Luminaire can be recognized from the Zhaga logo, which is applied to the product and/or its associated documentation, as well as the Zhaga Designation,<sup>2</sup> which provides information with respect to the performance of the product (such as beam pattern, light output, thermal characteristics, etcetera).

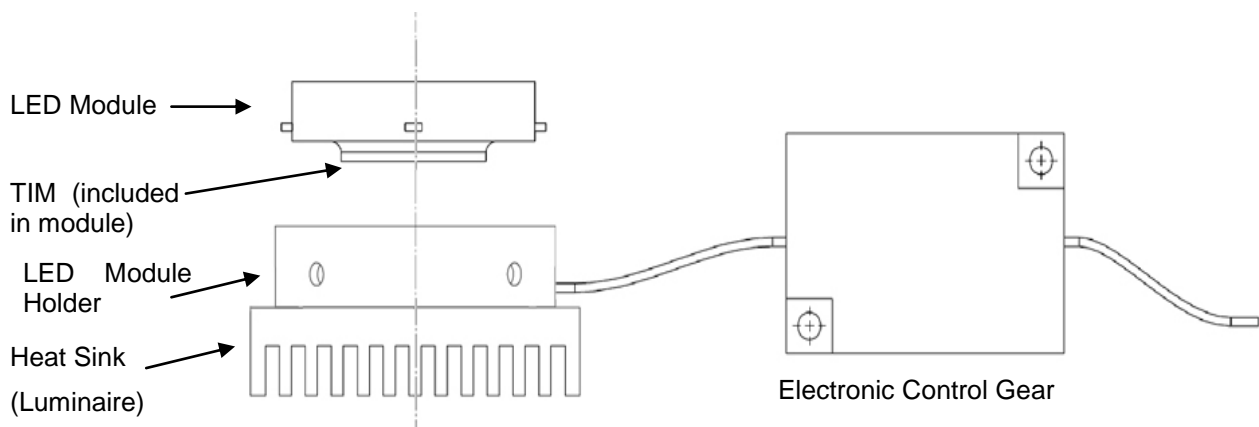
This Book 5 of the System Description Zhaga defines a Socketable spot LED Light Engine consisting of one or more LED Modules and an Electronic Control Gear physically separated from each other. The LED Module (which contains thermal interface material (TIM) from module manufacturer) is to be mounted to or into a Luminaire by an OEM Luminaire manufacturer by the means defined here. The ECG may be, but is not limited to being mounted to or into the Luminaire. The connection between them is not defined here and has to be done according to the prescription of the LED Light Engine manufacturer.

The Luminaire typically comprises means to guide the heat away from the LED Module and keep the temperature of the LED Module at a level the manufacturer defined limits to reach the performance and lifetime desired. The test procedures, setups, and marking requirements to ensure this capability are given in this document.

The Luminaire may or may not incorporate optical elements, which shape the light output of the LED module. The output of the LED module will have a defined distribution, per Section 4, which can be tailored into a specific distribution by the final Luminaire. The photometric interface of the LED module is specified in such a way that using different manufactures of Luminaire Optics, can produce similar Luminaire performance using the same LED module. The photometric specification has been carefully evaluated to yield "similar" performance without restricting the structure of the LLE or the LED technology as it is not the goal of Zhaga to limit technical innovation but to simply define and ensure interchangeability.

The mechanical interface for the LLE include provisions for mounting Luminaire Optics, Optics Contact Area (OCA) and maximum mechanical LED Module outlines to ensure different manufacturers can yield the same mechanical fit in any luminaire.

Figure 2-1 below illustrates the overall parts of the LLE and the luminaire.



**Figure 2-1 Schematic view of the assembly of LED Module, Luminaire with heat sink and Electronic Control Gear**

<sup>2</sup>See also Appendix D.3

## 3 Mechanical Interface

### 3.1 General

The LLE shall consist of one or more LED Module(s) and electronic control gear (ECG) for proper operation according to this specification. The LED Module may consist of several parts, which in some situations can be assembled by the OEM Luminaire manufacturer. The completely assembled LLE shall fulfill the requirements in this specification. Unless otherwise noted, within this specification dimensions are defined in a compressed state and all modules shall include TIM from module manufacturer.

### 3.2 Drawing principles

All technical drawings that define the mechanical interfaces in Section 3 are made according to the principles defined in [ISO 128]. In general, the drawings use the first angle projection method defined in [ISO 128-30]. Unless indicated otherwise, dimensions are in millimeters and assume measurement and verification at an ambient temperature of  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ .

The minimum and maximum values provided in tables that accompany the drawings represent absolute limits, without any implied tolerance (neither positive, nor negative); typical values as well as values between parentheses are informative, unless indicated otherwise.

The Reference Plane is the backplane of the LED Module as provided by the LLE manufacturer (including TIM material), the reference point is the point where the LED Module symmetry axis crosses the reference plane. Diameters are centered on the symmetry axis unless otherwise specified. Heights are specified relative to the reference plane unless otherwise specified. The positions of the reference entities are sketched in figure 3-1.<sup>3</sup>

Mechanical tolerances are standard molded plastics tolerances and originate from DIN 16901 group 140 set b.

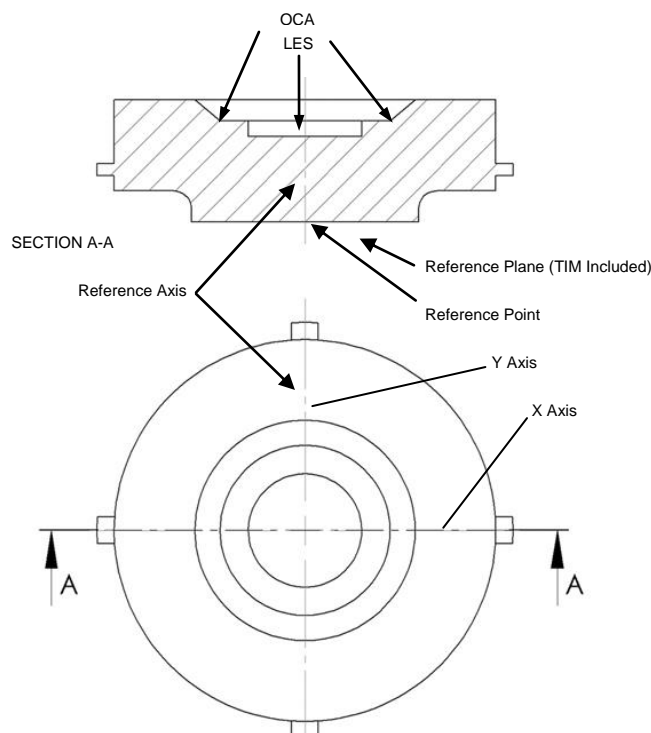
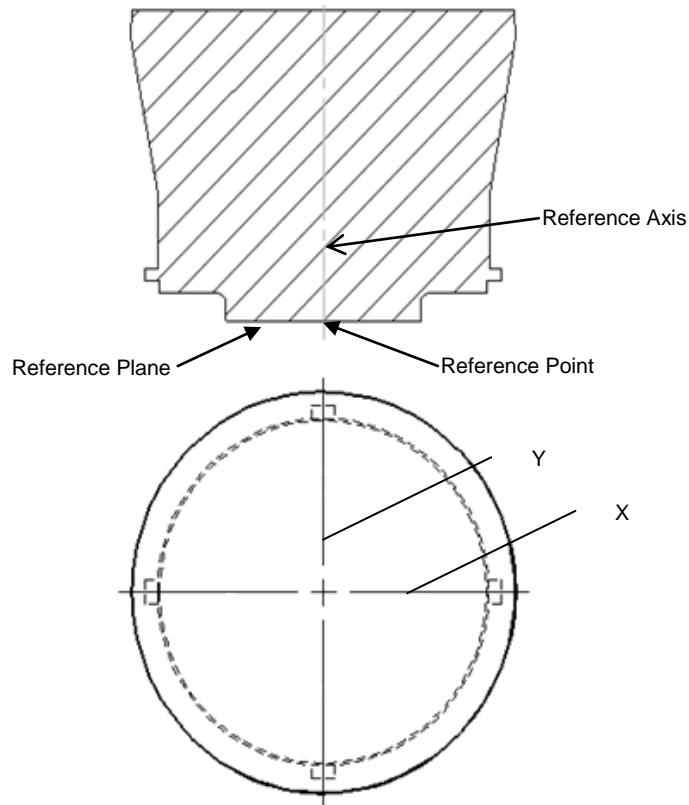


Figure 3-1 Positions of the reference point, reference plane and associated x & y axis for LED Module.

<sup>3</sup> The Z Axis is identical with the "Reference Axis" throughout this document.



**Figure 3-2 Positions of the reference point, reference plane and associated x & y axis for LED Module. with Integrated Optics**

### **3.2.1 Essentially Lambertian LED Module Outlines and common geometry**

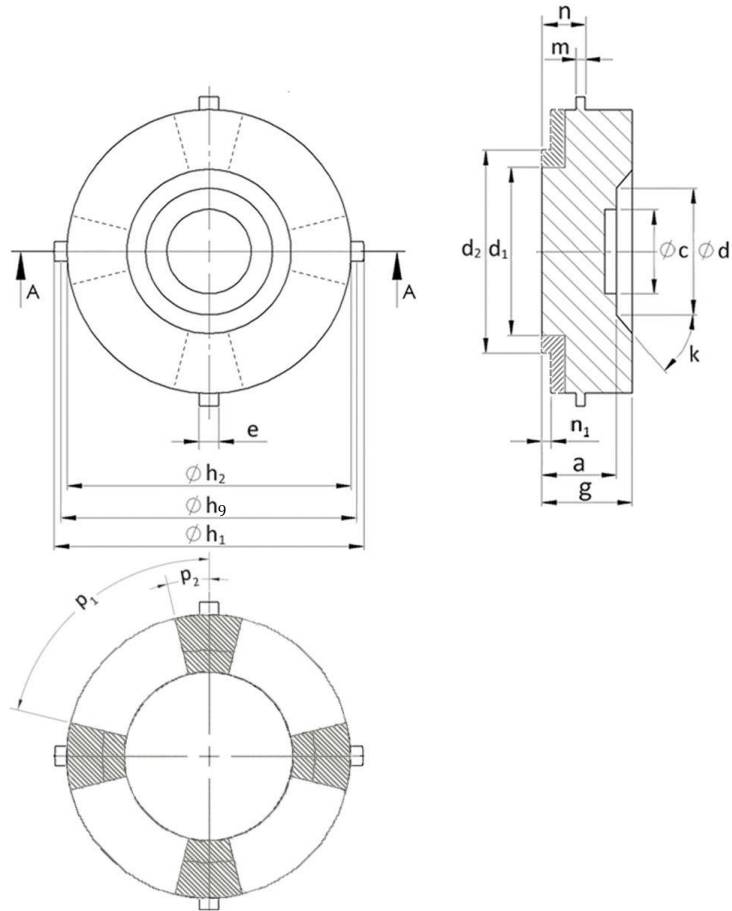
LED Modules specified in this section share the same maximum mechanical outlines with an essentially lambertian photometric output. The LED modules shall be round and have dimensions found within Table 3-1 below. The LED module dimensions are based on final engaged system or within the holder in section 3.5 Note that some parameters define only maximum outlines, meaning that the LED Module may also be smaller if technically feasible. Only the features relevant to compatibility like Optics Contact Area are specified with both-sided tolerances.



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**Figure 3-3 Drawing of mechanical dimensions of the LED Module**

Dimension	Min	Typical	Max
a	16,7	16,9	17,1
g	20,25	20,45	20,65
$\varnothing h_1$	69,50	69,75	69,87
$\varnothing h_2$	63,6	64	64,4
$\varnothing h_9$			65,49
$\varnothing d$	28,26	28,5	28,74
k	50°		
m		2,06	3,07
n	9,64	9,78	9,92
n1	2,49		
d1			39,0
d2			48,1
p1	76,3°		
p2			13,7°
e			4,70

**Table 3-1 Mechanical dimensions of LED Module**

LED modules should be round with a diameter designated by the parameter  $h_2$  and maximum width of  $h_1$ . Deviations from a perfect circle are allowed. However, the design shall ensure that Luminaire optics may be centered on the LED module OCA.

The dimensions in Table 3-1 are described as follows:

“a” is the height from the top of OCA plane to the bottom of the module (including thermal interface material.)

“g” is the overall height of the module.

“ $\varnothing h_1$ ” is the width from the outside of two opposite locking tabs.

“ $\varnothing h_2$ ” is the width of the module body, excluding the locking tabs.

“ $\varnothing h_9$ ” is the locking tab maximum fillet dimension.

“k” is the inclination angle of the side wall of the OCA, the minimum is defined to prevent interference with optics, no maximum defined, however dimension “g” shall be maintained.

“m” is the thickness of the locking tab. (Note dimension “n” defines the top of the surface, dimension “m” can extend in the downward direction to the maximum.)

“n” is the vertical distance between the top of the locking tab and the bottom of the module (including thermal interface material.)

“e” is the width of the locking tab.

“n1” is the height from the luminaire mounting plane to the underside of the outer flange of the module. This is an area to be considered for electrical connections and mechanical features as defined in later sections.

“d2” is the diameter of the outer portion of the lower mechanical design region (area where additional structure for mechanical fastening or springs may be located.)

“d1” is the diameter of the inner portion of the lower mechanical design region which subtends the lower edge of thermal spreader (area where additional structure for mechanical fastening or springs may be located) and is also the maximum diameter of the thermal interface area.

“p1” is the dimension for locating one edge of the mechanical design region (all four regions are symmetric around vertical and horizontal construction lines.)

“p2” is the dimension for locating one edge of the mechanical design region (all four regions are symmetric around vertical and horizontal construction lines.)

### 3.2.2 LED Module Electrical Interconnect

An electrical interconnect shall be placed in a minimum of one of the non-shaded areas as defined in bottom view in figure 3-3. The interconnect size shall not exceed the maximum outline given in Table 3-1. *Areas between shaded regions in bottom view of Figure 3-3 describe electrical interconnect regions on the bottom of the module and also allow for an area below the module for wires to pass through holder exit points.* When optional alignment tab (see section 3.2.4) is used, upper right quadrant shall be used to wires and electrical connection (quadrant directly opposite the alignment tab (See Figure 3-5.)

### 3.2.3 Mechanical Design Regions and Electrical Interconnect Keep Out Zones

*Below Figure 3-4 is a representation of the mechanical design region and the electrical interconnect keep out zones.*

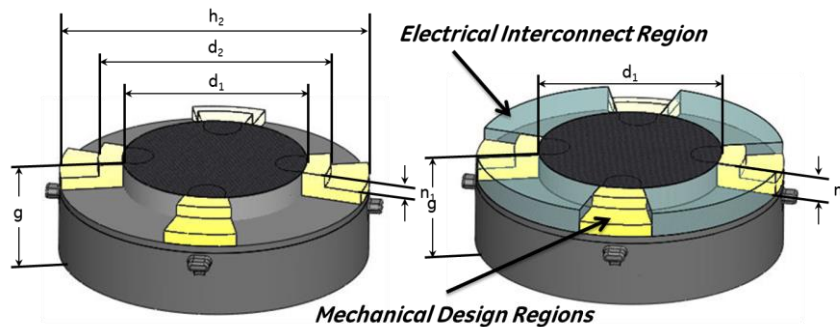


Figure 3-4 Informative Mechanical Design Region and Electrical Interconnect Regions

### 3.2.4 LED Module Optional Alignment Tab

Module manufacturers may produce a module which is not rotationally symmetric. In this case, an optional alignment tab may be used. Alignment tab should have same dimensions as the 4 other locking tabs on the module and is located per drawing in Figure 3-5.

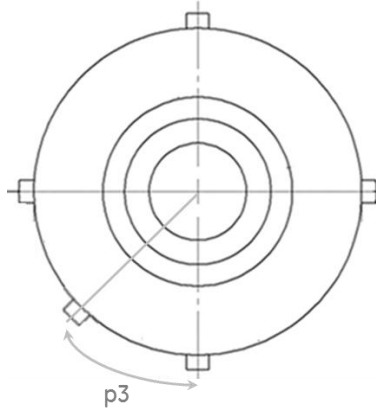


Figure 3-5 Optional Alignment Tab

Dimension	Min	Typical	Max
p3	44,5	45,0	45,5

Table 3-2 Mechanical dimensions of LLE

The dimensions in Table 3-2 are described as follows:

“p3” is the angular dimension for locating the center of the optional alignment tab.

### 3.2.5 LED Module Outlines and common geometry of other beam angles

LED Modules specified in this section share the same maximum mechanical outlines with pre-defined photometric beam angles based on the inclusion optics into the module. The LED modules shall be round and have dimensions found within Table 3-3 below. Additional dimensions for the module are already defined within Section 3.2.1 where J2 is a replacement for dimension "g" (excluding OCA and Light Emitting Surface - LES dimensions which are not applicable to this version.) The LED module dimensions are based on final engaged system or within the holder in section 3.5 Note that some parameters define only maximum outlines, meaning that the LED Module may also be smaller if technically feasible. Only the features relevant to interchangeability are specified with both-sided tolerances.

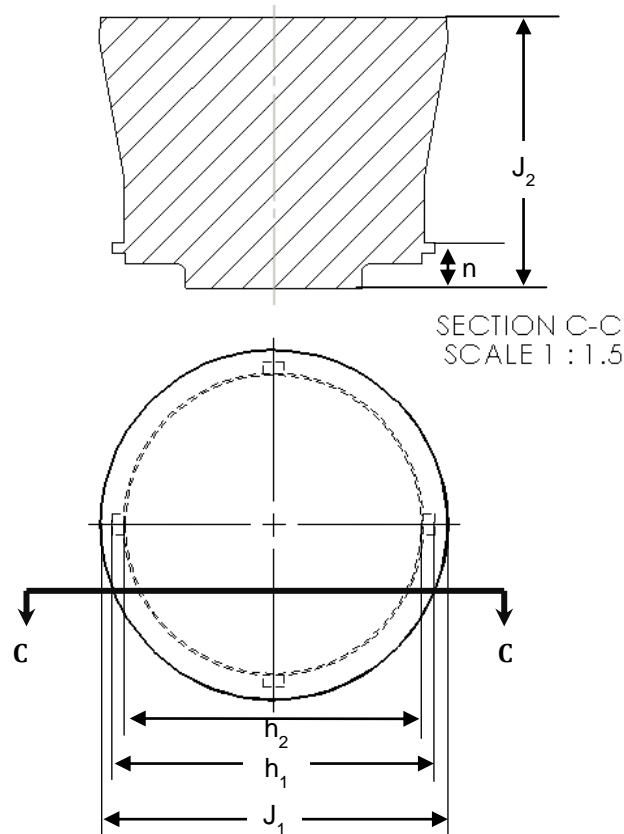


Figure 3-6 Drawing of mechanical dimensions of the LED Module with Integrated Optics (See Table 3-3)

Lumens	≤C011		C015-C020		C025-C030		>C030	
Beam Ang.	J1 (max)	J2 (max)	J1 (max)	J2 (max)	J1 (max)	J2 (max)	J1 (max)	J2 (max)
<15	140	113	160	180	180	180	--	--
15-25	100	113	150	180	180	180	--	--
25	80	55	90	100	100	100	--	--
35							--	--
>50							110	65

Table 3-3 Dimension J1 & J2 versus lumens and specified beam angles

The dimensions in Table 3-3 are described as follows:

“Øh<sub>2</sub>” is the diameter of the outer body of the module excluding the locking tabs.

“Øh<sub>1</sub>” is the diameter of the led module extent of the locking tabs (from edge to edge of opposite locking tabs.)

“n” is the height of the locking tabs top surface (excluding any ribs) to the bottom of the LED module (including thermal interface material.)

“J1” is the outer diameter of the optic at its widest location.

“J2” is the height of the module from the top of the optic to the bottom of the LED module (including thermal interface material.)

### 3.3 Luminaire keep out zones for interconnect

The Luminaire should foresee space for a connection as specified in Section 3.2.1 and illustrated in section 3.2.3.

*Note: In addition to these connection keep out zones, the thickness of connection wires needs to be taken into account.*

### 3.4 Optics Contact Area (Essentially Lambertian only)

The LED Module shall have a physical surface of the housing (“Optics Contact Area” – OCA) at a specified height and tolerance.<sup>4</sup> Drawing and dimensions see Figure 3-7 and 3-8, respectively. This requirement is only for LED modules that are of essentially lambertian type and do not contain any optical elements.

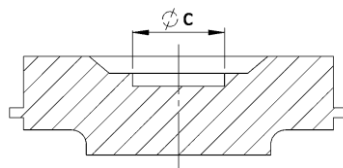


Figure 3-7 Dimensions of OCA's

The dimensions in Figure 3-6 are described as follows:

“Øc” is the diameter (from the middle of the module) of the OCA, (See Table 3-4 for allowable values for this dimension.)

<sup>4</sup> This is to ensure that a Luminaire Optics mounted at the Luminaire will fit without strain and with a maximum air gap of 0,5 mm when designed for an OCA height of 4 mm. The OCA needs to be a continuous surface. Special attention needs to be used to ensure that notches or similar within this surface do not allow light to “escape”.

There are 4 different variants of OCA dimensions, designated by the letters A, B, C, and D. The dimension  $\varnothing c$  of the OCA shall be associated to the OCA designation as defined in Table 3-4.

OCA Category	$\varnothing c$ Minimum	$\varnothing c$ Typical	$\varnothing c$ Maximum
OCA A	13,3	13,5	13,67
OCA B	18,83	19	19,17
OCA C	22,8	23	23,2
OCA D	25,8	26	26,2

Table 3-4  $\varnothing c$  dimensions and tolerances for different OCA categories

### 3.4.1 Inner Feature

Within the diameter  $\varnothing c$  defined in Section 3.4, the LED Module may contain any kind of mechanical “inner feature” like light mixing elements, mechanical holding elements, electrical insulation elements, etc., provided they do not exceed the height  $b$  as defined in Table 3-5.

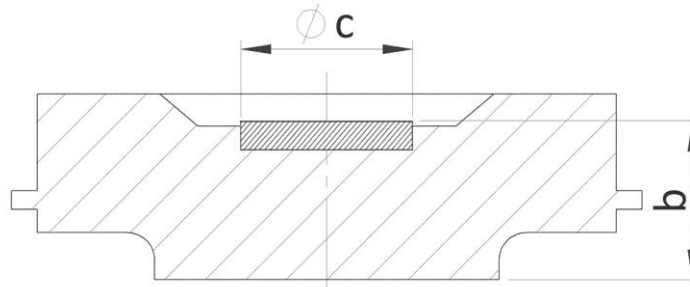


Figure 3-8 Maximum Inner Feature outlines (b vs. c)

OCA Category	b Maximum
OCA A	17,9
OCA B	18,4
OCA C	19,3
OCA D	20,1

Table 3-5 Maximum inner feature heights  $b$  for different OCA categories.

A dome or cover above one or more LEDs shall be allowed to exceed the height  $b$  max, if optical behaviour is not changed from a similar LES without dome or cover (See section 4.2). The maximum height of the dome or cover shall not exceed 20,1 mm (measured from the Reference Plane).

The dimensions in Table 3-5 are described as follows:

“ $b$ ” is the height of the top of the LES from the bottom of the LED module (including thermal interface material.) This dimension is defined in a compressed state.

### 3.5 Socketable LED Module Holder Feature

#### 3.5.1 Locking and seating features

The definitions in this section address the mechanical interface between the Socketable LED module and the complete LLE holder which can be a separate functional part or be integrated into the luminaire. The holder has 2 different types of features: one has a locking feature and the other does not. There are a total of 4 features per holder of which 2 shall be locking features. The locking and non-locking features are described in Figure 3-10. Informative picture of LED Module Holder is seen in Figure 3-9. There is also an included Alignment Tab “slot” which accepts the optional Alignment tab feature of the module.

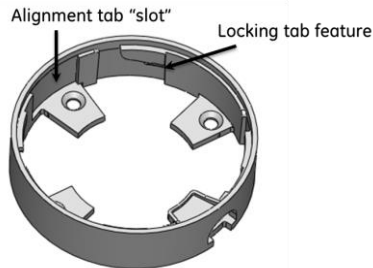


Figure 3-9 Informative picture of LED Module Holder

The LED module will be inserted into the final position by rotating the module past the retention lock which in the example below has an approximate minimum of 22.5°. In figure 3-9 optional screw holes are shown. The screw holes are to ensure that the holder is properly engaged to the luminaire using M4 screws (Note: M3.5 and #6 screws may also be used.)

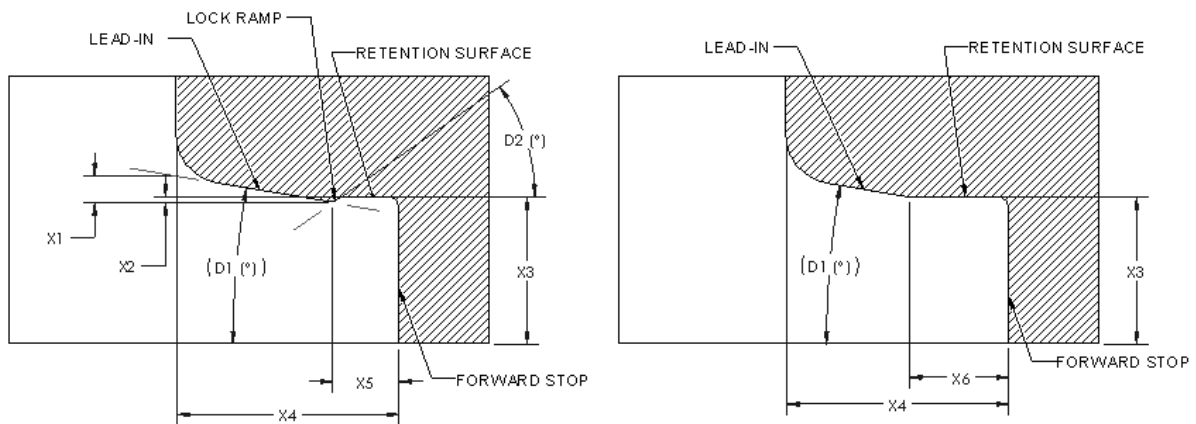


Figure 3-10 LED Module Holder locking and non-locking tabs<sup>5</sup>

<sup>5</sup> Figure 3-10 is a simplified projection onto a plane with no curvature, draft, or axial rotation lead-in features.

Dimension	Minimum	Typical	Maximum
X1	1,53	1,78	2,03
X2 <sup>6</sup>	0,25	0,38	0,51
X3	9,65	9,78	9,91
X4	14,48	14,73	14,98
X5	4,27	4,39	4,52
X6	6,35	6,60	6,85
D1		10	
D2		35	

**Table 3-6. Dimensions for LED Module Holder locking and non-locking tabs**

The dimensions in Table 3-6 are described as follows:

“X1” is the height of the lock ramp from end point of starting radius to lock ramp engagement point.

“X2” is the height of the lock ramp engagement point to retention surface.

“X3” is the height of the retention surface to the bottom edge of the holder.

“X4” is the length of the locking feature from start of lock feature to forward stop position.

“X5” is distance from lock ramp edge to the forward stop position.

“X6” is the length of the retention surface of non-locking tabs.

“D1” is angle of the lead-in to the bottom surface of the holder, this angle sets the amount of force required to insert the module.

“D2” is the angle of the backside of the lock ramp to the bottom surface of the holder; this angle sets the amount of engagement for the lock tabs.

### 3.5.2 Holder Dimensions and Definitions

The definitions in this section address the mechanical interface between the Socketable LED module and the complete LLE holder which can be a separate functional part or be integrated into the luminaire as an integral feature. The holder is composed of three primary features. As mentioned in section 3.5.1, the first primary feature is the set of locking and seating features which retain the module into the holder and an alignment tab slot. The second primary feature (only necessary when the holder is not integrated into the luminaire) is the set of four features of screws to retain the holder to the luminaire. The third primary feature is the called the “interconnect zone.” *Shaded region of Figure 3-11 is for thermal and potential electrical interconnect.* Figures 3-11 and 3-12 are drawing of the pertinent dimensions for the holder.

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<sup>6</sup> Only two of the four holder features needs this feature



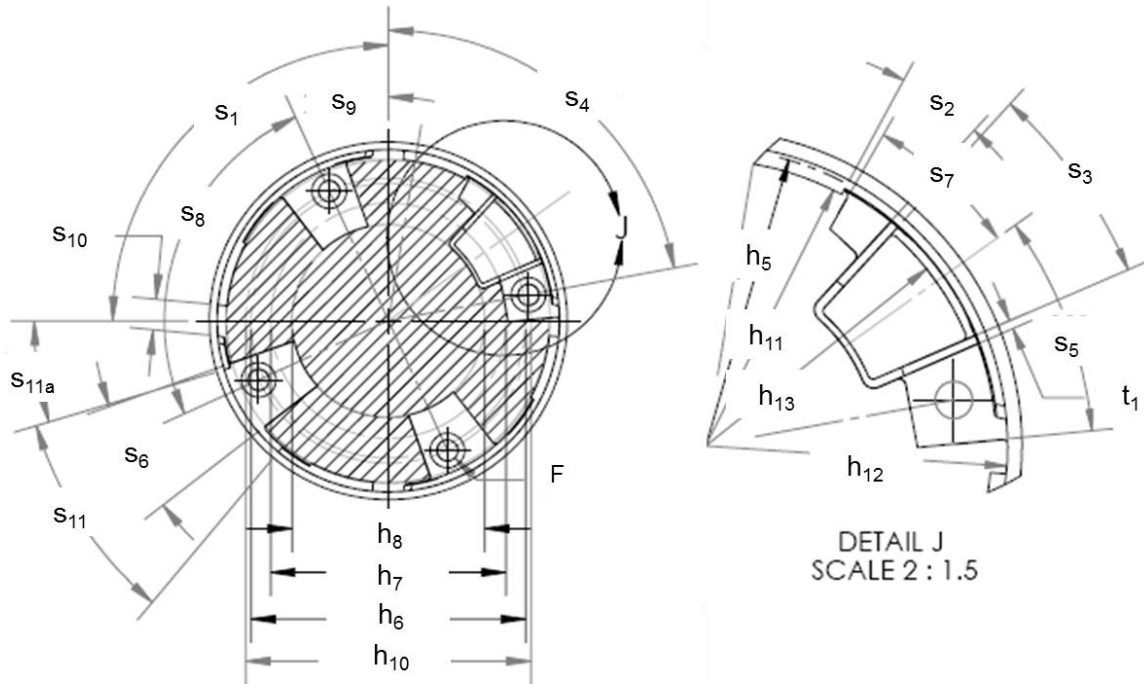


Figure 3-11 Drawing of Socketable LED module Holder

Dimension	Minimum	Typical	Maximum
S1		90°	
S2	13,85°	14,1°	14,35°
S3	23,5°	24,0°	24,5°
S4	79,25°	79,5°	79,75°
S5	29,5°	30,0°	30,5°
S6		18,2°	19,2°
S7	24,3°	24,8°	25,3°
S8	89,75°	90,0°	90,25°
S9	24,4°	24,65°	24,9°
S10	6,07	6,32	6,57
S11	33,4°		
S11a	16,1°	16,6°	17,1°
h5	69,84	70,0	70,16
h6 <sup>7</sup>	56,04	56,29	56,54
h7 <sup>7</sup>	47,99	48,24	48,49
h8	39,12	39,37	39,62
h10	58,28	58,42	58,56
h11	66,05	66,30	66,55

<sup>7</sup> This feature is for the optional screw hole for the holder. This feature has been designed for a M4 screw

h12	70,00	70,25	70,50
h13	65,52	65,66	65,80
t1	0,78	1,03	1,28
F	4,18	4,32	4,46

**Table 3-7 Dimensions of Socketable LED module holder**

The dimensions in Table 3-7 are described as follows:

- “S1” is the angle between two adjacent lock entry points
- “S2” is the angle between the lock tab forward stop and the first wall of the interconnect zone platform.
- “S3” is the angular extent of the interconnect zone
- “S4” is the angular definition for the screw hole adjacent to the connector mounting platform.
- “S5” is the outer edge of the lower screw mounting platform adjacent to the connector mounting platform.
- “S6” is the angular definition of the screw mounting platform opposite the connector mounting platform.
- “S7” is the angular definition of the lower edge keep-out zone for the upper plastic support feature location adjacent to the connector mount platform.
- “S8” is the angular definition of the screw holes opposite the connector mounting platform.
- “S9” is the angular definition of the opposite screw holes to the vertical datum of the socket.
- “S10” is the width of the opening for the locking tab in guide into the module holder.
- “S11” is the angular dimension defining the position of the alignment tab slot within the holder, relative to the holder mounting tab (this slot has same physical dimensions as the other non-locking holder slots, Figure 3-9.)
- “S11a” is the angular dimension defining the position of the alignment tab slot within the holder, relative to horizontal construction line within the figure. “H5” is the diameter from one lock tab seating surface to the opposite seating surface. The tight tolerance of  $\pm 0,13\text{mm}$  needs to only be held this location where the module lock tabs mate with the collar.
- “h5” is the outer radius defining the outer point of the interconnect zone.
- “h6” is the outer diameter of the keep-out zone for the upper plastic support feature location adjacent to the connector mount platform.
- “h7” is the outer diameter of the keep-out zone for the lower screw mounting location adjacent to the connector mount platform.
- “h8” is the inner radius defining the inner point of the interconnect zone
- “h10” is the diameter of screw locations for mounting socket to luminaire.
- “h11” is the diameter of the circle which defines the innermost portion of the holder; this is the area of material with which the module shall avoid to prevent interference with the holder.
- “h12” is the entry diameter of the socket for the lock tabs.
- “h13” is the diameter defining the inner edge of the outer wall of the connector mounting platform.
- “t1” is the thickness of the upper and lower boundary walls of the connector mounting platform.
- “F” is the diameter of the screw holes for holding down the module holder (when not integrated into the luminaire directly.)

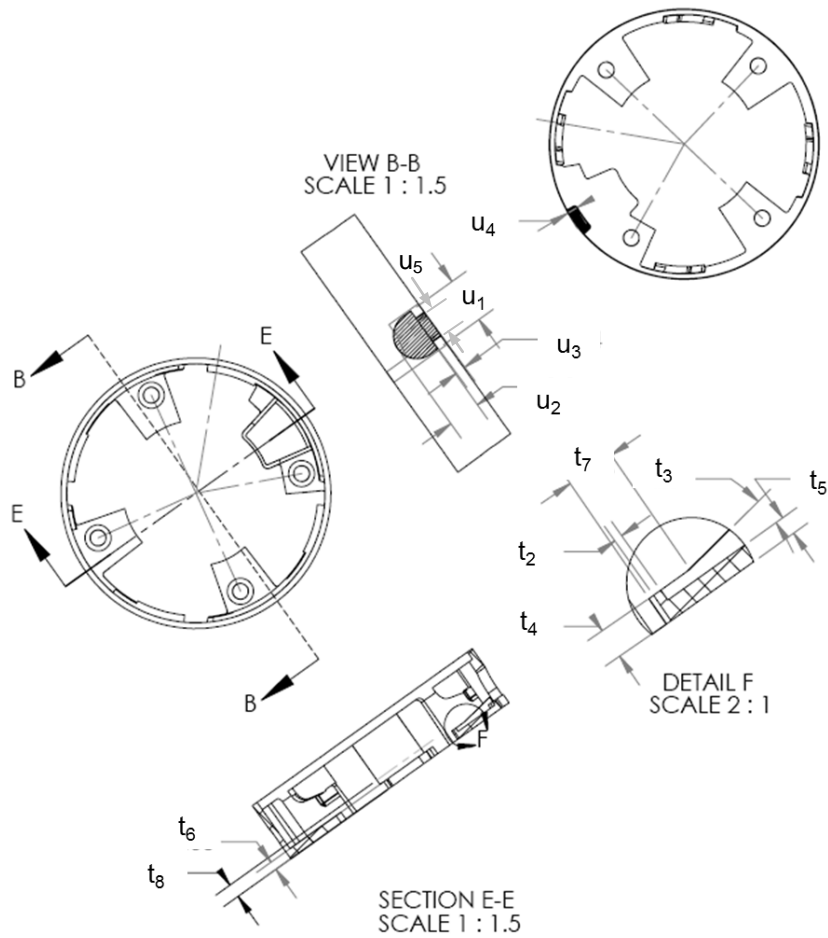


Figure 3-12 Drawing of Socketable LED module Holder (side view)

Dimension	Minimum	Typical	Maximum
t2	0,62	0,76	0,90
t3	8,8°	9,3°	9,8°
t4	2,54	2,79	3,04
t5	1,56	1,70	1,84
t6	2,11	2,36	2,61
t7	4,25	4,50	4,75
t8			3,86
u1	12,0	13,0	14,0
u2	8,4	8,9	9,4
u3	2,3	2,8	3,3
u4	2,4	2,9	3,4
u5			12,0

Table 3-8 Further Dimensions of Socketable LED module holder

The dimensions in Table 3-8 are described as follows:

“t2” is the thickness of the inner wall of the connector mounting platform.

“t3” is the angular definition of the support walls of the connector mounting platform.

“t4” is the height of the mounting platform walls (in non-angled section) from the mounting surface of the luminaire.

“t5” is the thickness of the floor of the connector mounting platform.

“t6” is the thickness of screw mounting platforms (only necessary when socket feature is not integrated into the luminaire base.)

“t7” is the distance from the inner most edge of the connector mounting platform to the point at which the support wall angles upward.

“t8” is the maximum height of the screw head above the luminaire plane.

“u1” is the diameter of the exit hole from socket.

“u2” is height of the exit hole from the socket.

“u3” is height of the lower edge flange of the exit hole.

“u4” is the depth of the slot for exit hole from the socket (feature to allow Z direction exit of wires from the holder).

“u5” is the width of slot for the exit hole from socket (feature to allow Z direction exit of wires from the holder).

### 3.6 Luminaire mechanical properties and the LED module

The Thermal Interface Surface of the Luminaire and LED module is shown below in Figure 3-13. As the thermal path is the one of the most critical interfaces between LED Module and Luminaire, and such special demands apply. The Thermal Interface Surface of the Luminaire should be equivalent to or better than the defined features of the Test Fixture RthTF-Spot. The Thermal Interface Surface should have a surface planarity smaller than 0,1 mm and a surface roughness smaller than 3,2  $\mu\text{m}$ . It is recommended to use aluminum alloy with a good thermal conductivity and a thickness of at least 2 mm.<sup>8</sup>

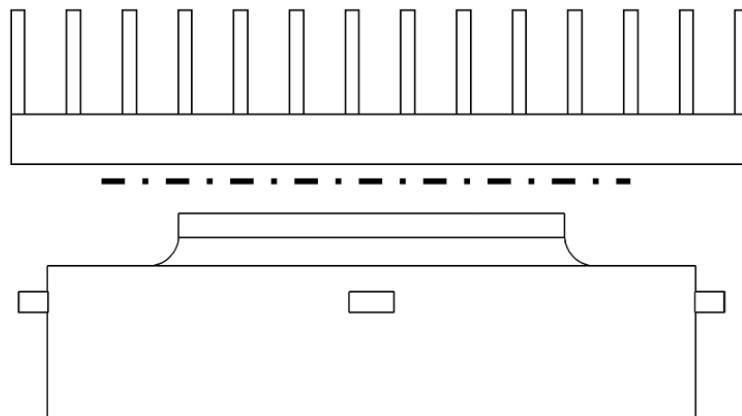


Figure 3-13 Basic structure of Luminaire heat sink part

### 3.7 Mechanical dimensions of ECG

The mechanical dimensions of the ECG will be defined in a Book 1.

<sup>8</sup> See also Annex A.4.2

### **3.8 Luminaire ECG mounting surface**

The mechanical dimensions of the ECG and the requirements to the mounting surface are defined in Book 1.

## 4 Photometric Interface

### 4.1 General

The LED Module shall emit light in two potential embodiments; firstly a “lambertian” distribution in the direction of the module’s symmetry axis and secondly a non-lambertian beam pattern from integrated optics. Associated to the specific light emission of the “essentially lambertian” LED module is a Light Emitting Surface characterized by its height and diameter. There are 4 different diameter categories specified here. Categories are also specified for Luminous Flux and Correlated Color Temperature.

### 4.2 Light Emitting Surface (LES)

The LES shall be described by a 2-dimensional circle having the smallest possible diameter to fulfil the following principles. The LES shall be parallel to the reference surface defined in Section 3.2. It has a physical boundary or is a virtual surface in the surrounding area of the LED module. This section is only for socketable LED modules that do not have a specified beam angle and whose photometric properties are essentially lambertian.

The LED Light Engine manufacturer specifies position and diameter of the LES according to the following principles:

1. The horizontal position of the center of the LES is the photometric center of the light emission
2. When seen from above, all parts of the light emitting area (LED Chip, LED package, diffusing cover and / or mixing chamber) are covered by the LES.
3. The position in height ( $hp$ ) of the LES shall be chosen in that way, that all light emitting parts are behind the LES, when seen from top view and a substantial amount of the emitted Luminous Flux is expected to pass the LES.
4. A dome or cover above one more LEDs shall be allowed to exceed the LES height,  $hp$ , if optical behaviour is not changed from a similar LES without dome or cover.

Examples for defining LES diameters:

- a) LES is located around the domed cover of a multichip, phosphor covered LED.
- b) LES is located around the silicone domes of single LEDs in the LED Module. The LES diameter is large enough to encircle all LED domes completely.
- c) In case the LEDs are encircled by the nearly vertical walls of a light guiding, mixing or diffusing element, the LES should be described by the opening of this element.
- d) In the case of a diffuse cover covering the LEDs, the LES shall be described by the functional area of the diffuse cover.

Regarding the LES dimensions and tolerances, the following requirements shall apply:

1. The center of the LES shall not vary from the symmetry axis of the module by more than 1 mm in any direction.
2. The typical height  $hp$  of the LES shall be 4 mm. This height should be taken as a reference by the Luminaire manufacturer in designing Luminaire Optics. Minimum value of  $hp$  is 2 mm, maximum value is the  $b$  value of the associated OCA as defined in Table 3-5.
3. LES diameters are categorized and labelled into four groups designated as LES 9, LES 13.5, LES 19, LES 23. The physical boundaries/dimensions for these categories are found in Table 4-1.

LES Category	Minimum LES Diameter	Maximum LES Diameter
LES 9	6,3	9
LES 13.5	9	13,5
LES 19	13,5	19
LES 23	19	23

Table 4-1 Maximum and Minimum Diameter of LES

#### 4.2.1 LLE with specified Beam Angle LES size

In LLE's that have a specified beam angle there is no specification for LES size. The manufacturer of the LLE shall specify beam angle, center beam candle power (CBCP), and flux per CIE 84

#### 4.2.2 LES diameter vs. OCA

In order to achieve mechanical interchangeability for LED modules with the same LES diameter, the following relations shall be kept:

LES Category	Minimum LES Diameter	Maximum LES Diameter	OCA Category	b (max)
LES 9	6,3	9	OCA A,B,C,D	17,9
LES 13.5	9	13,5	OCA A,B,C,D	18,4
LES 19	13,5	19	OCA B,C,D	19,3
LES 23	19	23	OCA C,D	20,1

Table 4-2 Max OCA versus LES diameter and B dimension

### 4.3 Luminous Flux

#### 4.3.1 Luminous Flux Table

The Initial Luminous Flux of an LLE measured under the conditions specified in Section A.3.2 shall be in one of the categories listed in Table 4-3. The Luminous Flux shall be reported on the product data sheet of the LLE by the manufacturer.

Flux category	Total Luminous Flux		
	Minimum	Typical	Maximum
C001	--	100	200
C002	180	200	300
C003	270	300	400
C004	360	400	600
C006	540	600	800
C008	720	800	1100
C011	990	1100	1500
C015	1350	1500	2000
C020	1800	2000	2500
C025	2250	2500	3000
C030	2700	3000	4000

C040	3600	4000	5000
C050	4500	5000	6000
C060	5400	6000	7000
C070	6300	7000	8000
C080	7200	8000	10000
C100	9000	10000	--

Table 4-3 Luminous Flux categories

#### 4.4 Luminous intensity distribution<sup>9</sup>

The luminous intensity distribution of an LLE shall be measured under the conditions specified in Section A.3.2, with C-slices<sup>10</sup> at least every 15° and polar angles at least every 2,5°<sup>11</sup> for wide angle, beams with no significant beam structure. For medium flood or narrower beam patterns or systems with integrated optics and for beams with apparent beam structure, perform C-slices every 5° and azimuth angles in 0,5° resolution or the necessary resolution needed to fully resolve beam pattern structure. As only relative values are to be considered for luminous intensity distribution,  $t_r$  may be allowed to stabilize at any temperature (not necessarily next to  $t_{Rmax}$ ), unless any absolute values (like Luminous Flux) are to be measured in the same measurement.

It is recommended that the LLE has a luminous intensity distribution that is as close as possible to a lambertian intensity distribution (essentially lambertian in nature) except for those modules which include optics (see section 4.5 for additional luminance property requirements.)

There is no requirement regarding FWHM of the luminous intensity distribution.

Relative Partial Luminous Fluxes for the polar angle regions as defined in [CIE 52] (“CIE cumulative flux zones”) shall be determined from the measurement and rounded to full percent numbers. For each of these regions, the tolerances in Table 4-4 apply.

CIE Cumulative flux zone	$\gamma$ -Angles (All C-planes)	Minimum of Partial Luminous Flux	Maximum of Partial Luminous Flux
FC1	0° - 41,4°	39%	56%
FC2 – FC1	41,4° - 60°	31%	37%
FC3 – FC2	60° - 75,5°	11%	22%
FC4 – FC3	75,5° - 90°	0%	7%

Table 4-4 Relative Partial Luminous Flux Tolerances

Polar Angle	C-Slices (azimuth angle)	Maximum Deviation from Average Curve
-60° - 60°	All	+/-20%
-75° to -65° and 65° to 75°	0° to 45° and 135° to 165°	+/-40%

<sup>9</sup> This section only pertains to Socketable LED modules that do not have specified beam angles and whose photometric properties are essentially lambertian

<sup>10</sup> For definition of “C-Slices” see [CIE 121].

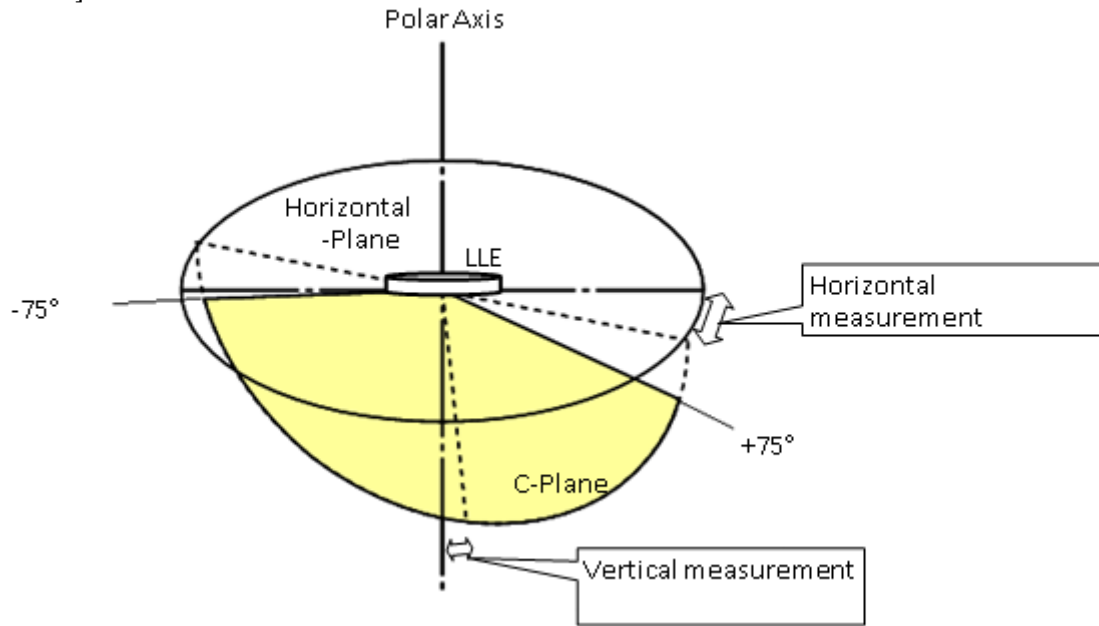
<sup>11</sup> This is in line with [EN 13032-2].



-75° to -65° and 65° to 75°	60° to 120°	NA
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**Table 4-5 Limits for Rotational Symmetry**

Rotational symmetry of the luminous intensity distribution is evaluated from the goniometric data. The average Luminous Intensity curve (Luminous Intensity versus polar angle) is calculated as the average of Luminous Intensities in all C-slices for every polar angle. The deviation from the average curve has the limits shown in Table 4-5<sup>12</sup> Figure 4-1 is the schematic explanation of measurement procedure according to [CIE121].



**Figure 4-1 Schematic explanation of measurement**

**4.4.1 Luminous intensity distribution for specified beam angles**

In socketable LLE's that have a specified beam angle the manufacturer of the LLE shall specify beam angle and flux per CIE 84 & IEC 61231.

The following categorization shall be used and reported with the nominal beam angle.

Beam Angle Category	Angle (degree)	
	Minimum	Maximum
<b>6</b>	3°	9°
<b>12</b>	9°	15°
<b>17.5</b>	15°	21°
<b>25</b>	21°	29°
<b>35</b>	29°	41°
<b>55</b>	41°	70°
<b>90</b>	70°	110°
<b>120</b>	110°	150°

<sup>12</sup>This exception honors the observation that the screw cutout in the housing may have a significant influence on light output in these angles, which has no impact on performance with a reflector starting at the OCA.

Table 4-6 Luminous intensity distribution for specified beam angles

#### 4.5 Luminance properties<sup>13</sup>

Luminance of the LLE should be symmetric with respect to the reference axis. The minimum symmetry requirement is defined as follows:

The LES category diameter shall be divided into five segments  $A_i$  ( $i=1\dots5$ ) as shown in Figure 4-2.

##### 4.5.1 Luminance rotational symmetry

The Luminance rotational symmetry parameter  $S$  is calculated from the average luminance  $L_i$  in forward direction in each of the four segments  $A_i$  ( $i=1\dots4$ ) as  $S = \min(L_i)/\max(L_i)$ . The value of  $S$  shall not be lower than 0,5. It shall be reported in the product data sheet.

##### 4.5.2 Luminance center balance

The average luminance  $L_i$  in forward direction in segment  $A_5$  with respect to the average of the four segments  $A_1 - A_4$  shall fulfill the criterion  $L_5/\text{average}(L_{1-4}) < 4$ .<sup>14</sup>

##### 4.5.3 Luminance uniformity

The ratio between areas having more than 80% of the average luminance of the LED module to the actual LES diameter<sup>15</sup> area shall be stated as uniformity parameter  $U$  in the product data sheet. Details on how to determine  $U$  can be found in Annex A.3.<sup>16, 17</sup>

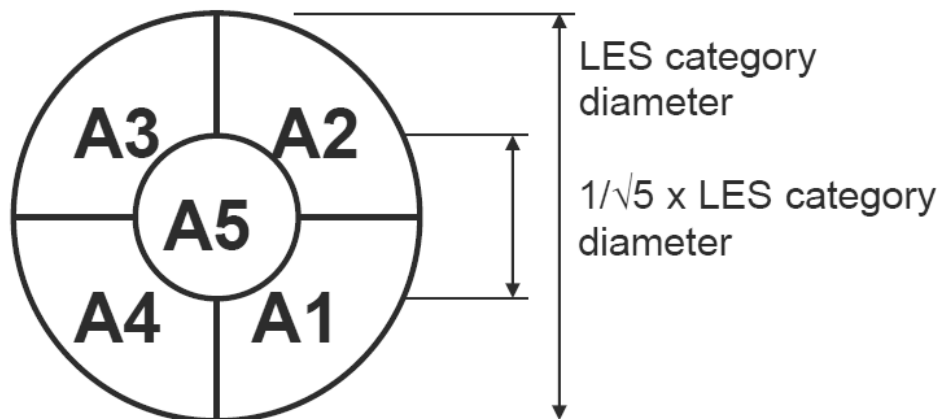


Figure 4-2 Luminance property evaluation areas

#### 4.6 Chromaticity Coordinates (CCx, CCy)

The chromaticity coordinate (CCx, CCy) of the LLE spectrum shall comply with the designated CCT category found therein [ANSI C78.377]<sup>18</sup>, with the exception that the target color points may be chosen

<sup>13</sup> This section only pertains to Socketable LED modules that do not have specified beam angles and whose photometric properties are essentially lambertian

<sup>14</sup> This initial limit might be refined in a later version of this specification. Special requirements for non-circular (e.g. rectangular) LES shapes are under consideration.

<sup>15</sup> For this requirement, not the LES category diameter but the actual LES diameter determined in Section 4.2 shall be used.

<sup>16</sup> Uniformity parameter  $U$  is only sensitive to brightness uniformity. Color uniformity in case of modules consisting of differently colored LEDs may introduce additional inhomogenities. This should be mentioned in the LLE product data sheet. Further elaboration for  $U$  will be done for a later version.

<sup>17</sup>  $U$  is not sensitive for small-sized brightness "spikes" in the luminance. This is also to be taken into account in a later version.

freely within the quadrangles defined therein.<sup>19</sup> It is recommended to use the nominal CCT values specified in [ANSI C78.377] only. However, also the “open category” defined therein may be used.

#### 4.7 Color rendering index

This version of Book 5 of the System Description Zhaga does not define limits on the color rendering index of a Spot LLE with separated ECG. However, this version 1 of Book 5 of the System Description Zhaga does require the product data sheet of a Spot LLE with separated ECG to provide the color rendering index at the Rated operating temperature (see Annex D.1). Other color rendering metrics like the color quality scale (CQS) may be published in addition.

#### 4.8 Luminaire Optics <sup>20</sup>

Luminaire Optics (e.g., reflectors) should be designed in such a way, that the nominal values of LES diameter and height with a lambertian emission pattern result in the desired performance.

Luminaire Optics may be mounted in contact with the OCA corresponding to the LES diameter category it is designed for according to Section 4.2.2.

*Note: (informative) Due to the compound nature of many LED module solutions, it is expected that Luminaire Optics designed for Zhaga compliant Spot LLEs takes into account the structure of LED clusters, e.g. by using frosted surfaces or faceted structures to achieve the comparable light output with all kinds of module technologies enabled by the Zhaga Specifications. The luminance uniformity factor U of the LED Module can give a hint on the degree of effort necessary to achieve properly distributed light with Luminaire Optics.*

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<sup>18</sup> In that document the following CCT categories ‘2700K’, ‘3000K’, ‘3500K’, ‘4000K’, ‘4500K’, ‘5700K’, and ‘6500K’ can be found.

<sup>19</sup>Note that notwithstanding this exception, a Spot LLE shall have a CCT that is within the quadrangle of the Rated CCT.

<sup>20</sup> This section only pertains to Socketable LED modules that do not have specified beam angles and whose photometric properties are essentially lambertian

## **5 Electrical Interface**

### **5.1 General**

The Socketable LLE consists of one or more LED Modules and accompanying ECG. The ECG is intended to be driven primarily by mains power.

### **5.2 Mains input**

#### **5.2.1 Spot LLE mains power requirements**

Individual requirements of the ECG shall be defined in the respective product data sheet and on the LLE or ECG respectively.

#### **5.2.2 Insulation requirements for LLE**

This specification version 1.1 does not require specific means of insulation for the LLE. Reference is made to [IEC 60598].

## 6 Thermal Interface

### 6.1 Thermal Interface Model

Please reference Zhaga Book 1 Section 6.2.1 for definition and description of the “Thermal Interface Model.”

### 6.2 Luminaire Thermal requirements

The Luminaire shall contain heat sinking features that enable the heat generated by the LED module to be conducted to the ambient. The rated thermal resistance of the Luminaire,  $R_{th}$  shall be marked according to Annex D.1.1.

For Luminaires intended for use with multiple LED Modules and / or multiple LLEs, reference Book 1 Section 6 for additional details.

### 6.3 Interchangeability criteria

In order to determine if—from a thermal point of view—a particular LLE can be used reliably in a particular Luminaire, it shall be verified before mounting the LLE that the applicable thermal resistance of the Luminaire ( $R_{th}$ ) is less than or equal to the maximum thermal resistance  $R_{th,max}$  specified in the product data sheet of the LLE (Annex D.1.) The applicable thermal resistance can be linearly approximated from thermal resistances corresponding to thermal powers above and below the actual LED Module thermal power. In cases of doubt or incomplete data, the thermal resistance of a power lower than the actual LED Module power shall be chosen for evaluation.

*Note: (Informative) In case of a closed Luminaire design, the maximum total thermal power  $P_{th}$  should be used instead of the maximum thermal power applied at the Thermal Interface Surface  $P_{th,rear}$ .*

*Note: (Informative) The thermal power generated by the ECG is not considered in this version 1.1 of the specification. It has to be evaluated whether it needs to be considered with a safety margin.*

*Note: (Informative) As an example, consider the information listed in the product data sheets of particular LLE and open Luminaires:*

	Manufacturer data sheet #1	Manufacturer data sheet #2
LED module data sheets:		
Maximum total thermal power [W]	23	38
Maximum thermal power applied at the Thermal Interface $P_{th,rear,max}$ [W]	18	35
Maximum allowable thermal resistance of the Luminaire $R_{th,max}$ [K/W]	2,3	1

*These values are valid for an ambient temperature  $t_a=25^\circ\text{C}$ .*

	Manufacturer data sheet #1	Manufacturer data sheet #2
Luminaire data sheets		
Thermal Resistance $R_{th}$ at 10 W [K/W]	2,2	1,5
Thermal Resistance $R_{th}$ at 20 W [K/W]	1,9	1,4
Thermal Resistance $R_{th}$ at 30 W [K/W]	1,7	0,9
Thermal Resistance $R_{th}$ at 40 W [K/W]	1,6	0,7

*These values are valid for an ambient temperature  $t_a=25^\circ\text{C}$ .*

*Values for  $R_{th}$  at different Powers can be calculated by linear interpolation.*

*From these numbers it can be seen that the performance of LED module #1 can meet specifications in Luminaire #1 and #2 (because  $2,2 < 2,3$  , and  $1,5 < 2,3$  ), whereas LED module #2 can only meet specifications in Luminaire #2 only (because  $1,7 > 1$  and  $0,9 < 1$  ).*

## **7 Controls**

This book does not define means to control the light output characteristics of the socketable LLE other than mains power on/off. Socketable LLE products that do include control functionality shall provide relevant information on the product data sheet.

In particular, Socketable LLE and Luminaire products may include dimming functionality. Whereas this book does not define a specific technology to realize such dimming functionality, the product data sheet shall provide at least the following information:

The dimming technology implemented—such as forward phase, reverse phase, 0-10V, DALI, etc.

The ratio of the minimum and maximum total Luminous Flux—i.e. a dimming percentage such as 10%, 20%, etc.

In addition, it is recommended that the product data sheet provides information on compatible controls.

## Annex A LLE Compliance Testing (Normative)

### A.1 General

All tests defined in this Annex shall be performed on 1 specimen of a Socketable LLE.

### A.2 Mechanical testing

#### A.2.1 Testing equipment and conditions

##### A.2.1.1 Gauges

The mechanical dimensions shall be tested with gauges and either calipers or (semi-)automated 3D measuring equipment. Measurement accuracy of better than +/- 0,05 mm is recommended. The following gauges shall be used to perform the mechanical interface tests. All mechanical dimensions specified in Sections 3.2 through 3.5 shall be verified at an ambient temperature of 25°C ± 5°C.

This section defines gauges to be used to verify critical dimensions. Other mechanical dimensions may be confirmed using other means.

Section	Gauge Name	Purpose
A.2.1.2	H-H5a	To check the lock tab mating feature on the holder, dimension H5 minimum
A.2.1.2	H-H5b	To check the lock tab mating feature on the holder, dimension H5 maximum
A.2.1.3	M-LT2	Gauge with collar features to test compressed state dimensions
A.2.1.4	M-LT1	To check LED module locking tab and module body maximum diameter
A.2.1.5	H-KO1	To check holder hole locations and keep out zones
A.2.1.6	M-EK01	To check LED module electrical keep out zone
A.2.1.7	M-OD1	To check maximum diameter of module with integrated optics

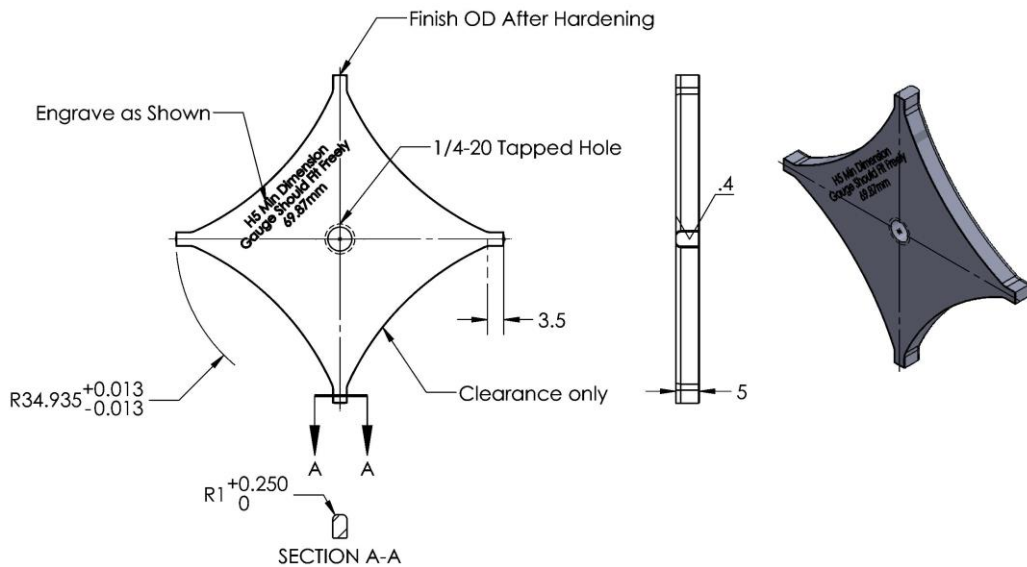
Table A - 1

**A.2.1.2 Gauge H-H5a and H-H5b**

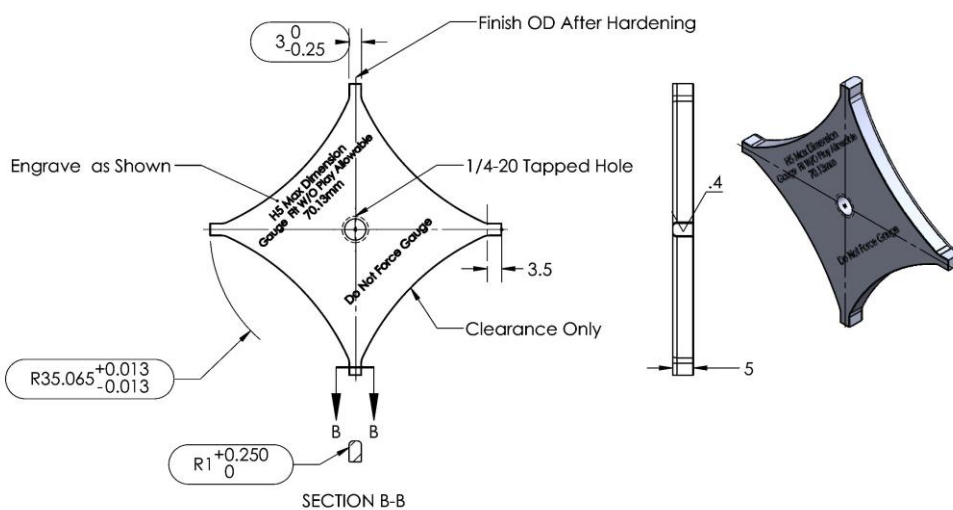
Figures A-1, A-2 and A-3 define gauges H-H5a, H-H5b and the Gauge Handle

Purpose: To check holder dimension H5 Minimum (H-H5a) and H5 Maximum (H-H5b)

Testing: Place the LLE Holder under test on a flat surface, luminaire mounting side down, fastened tightly to eliminate any flexing (use mounting holes as needed) and put the gauge on “text marked” surface facing up. Slide the gauge into the LLE holder under test. The maximum gauge shall not pass through the holder (deformation of holder not allowed) and the minimum gauge shall pass without force into the holder (deformation of holder not allowed).



**Figure A-1 Gauge H-H5a for Holder Dimension H5**



**Figure A-----2 Gauge H-H5b for Holder Dimension H5**



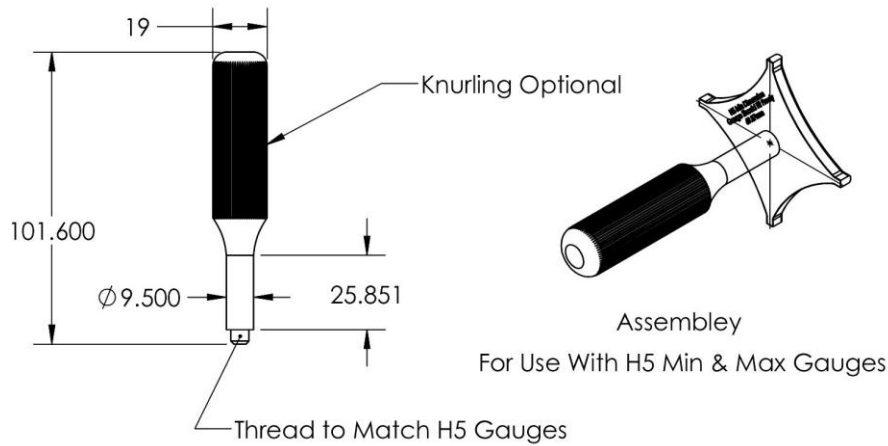


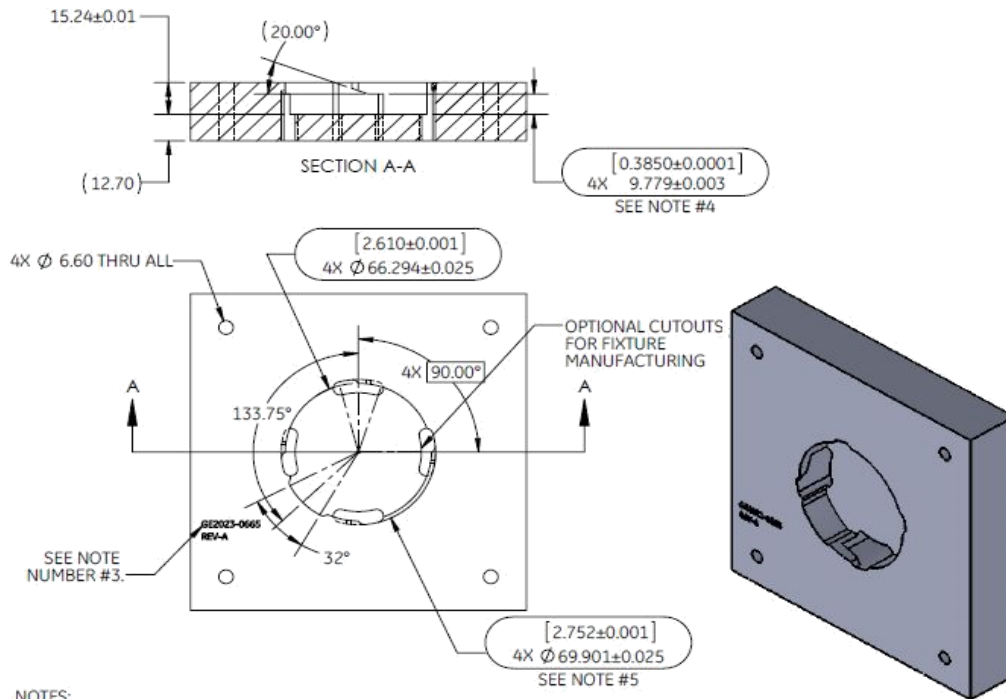
Figure A-3 Gauge H-5 Handle for use with H-H5a and H-H5b

### A.2.1.3 Gauge M-LT2

Figure A-4 defines gauge M-LT2 to compress modules.

Purpose: To install an LLE to create a compressed state, used for measuring dimensions which are required to be confirmed in a compressed state. This gauge is only for conditioning the module for measuring compressed dimensions, this is not a pass or fail gauge.

Testing: Place gauge on a flat surface. Place module into gauge in a face-up orientation. Twist module into position until unit is equally compressed. Compressed measurements may require the use of collar gauge M-LT2 attached to a flat fixed plate.



NOTES:

1. MATERIAL: 52100 STEEL, HEAT TREATED, HARDEN TO 60-62 ROCKWELL C. USE OF ALTERNATE MATERIAL REQUIRES WRITTEN APPROVAL FROM ENGINEERING DEPARTMENT.
2. BREAK SHARP EDGES.
3. PERMANENTLY MARK FIXTURE WITH PART NUMBER, MAY ENGRAVE, SCRIBE, ADD NAMEPLATE, ETC. ALSO ADD REVISION CALLOUT TO SHOW CURRENT REV LEVEL OF FIXTURE. REVS CAN SIMPLY BE ADDED TO FIXTURE WITHOUT NEED TO REMOVE PREVIOUS CALLOUT. LATEST REV SHOWN WILL BE CONSIDERED IDENTIFYING REVISION.
4. CRITICAL FUNCTION OF FIXTURE TO CHECK HEIGHT OF NOMINAL DESIGN CONDITION OF MATING COLLAR / SOCKET OF MODULE: 0.385".
5. FIXTURE ID TO LOCK TAB: 2.746" (MODULE NOMINAL) + 0.005" (MODULE TOLERANCE) + 0.001" (FIXTURE TOLERANCE) = 2.752".
6. CRITICAL INSPECTION DIMENSIONS IDENTIFIED BY INSPECTION SYMBOL. PROVIDE INSPECTION REPORT TO VERIFY CONFORMANCE TO DESIGN.

Figure A-4 Gauge M-LT2 for compressing LLE.





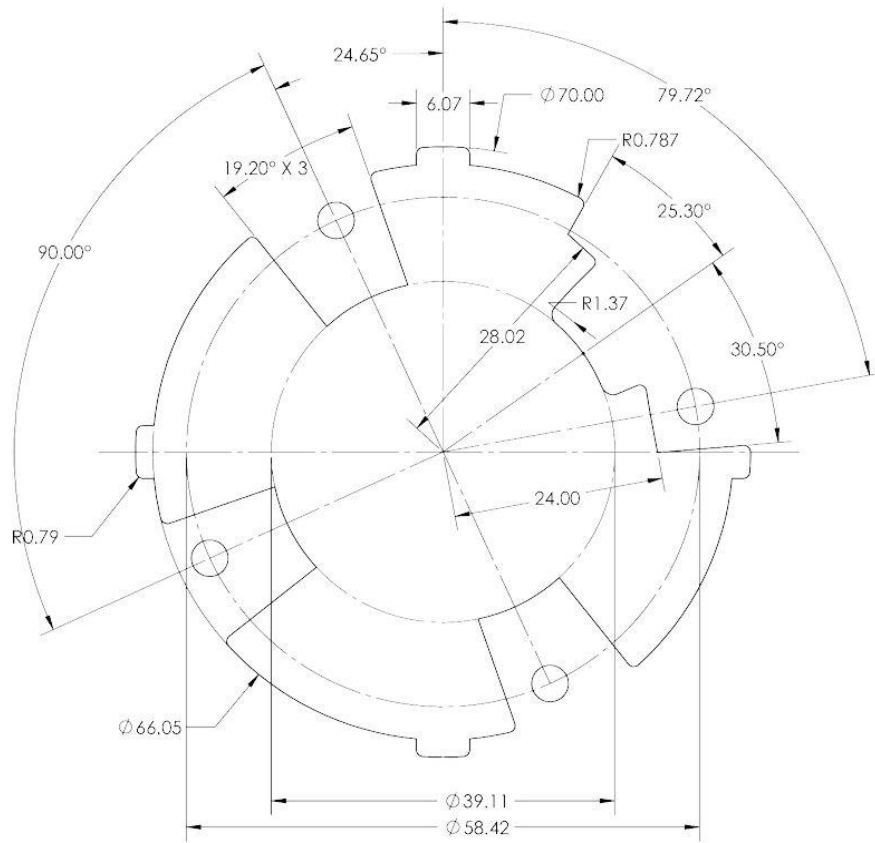


Figure A-7 Gauge H-K01 Detail for Outside Form

**A.2.1.6 Gauge M-EK01**

Figure A-8 defines gauge M-EK01.

Purpose: To check LED module for acceptance to electrical “keep out” zone.

Testing: Place gauge on a flat surface. Place the test LED module into gauge in a face-up orientation. If module freely seats into the gauge with no undue force, without obstruction or deformation of the module, then the test LED module passes.

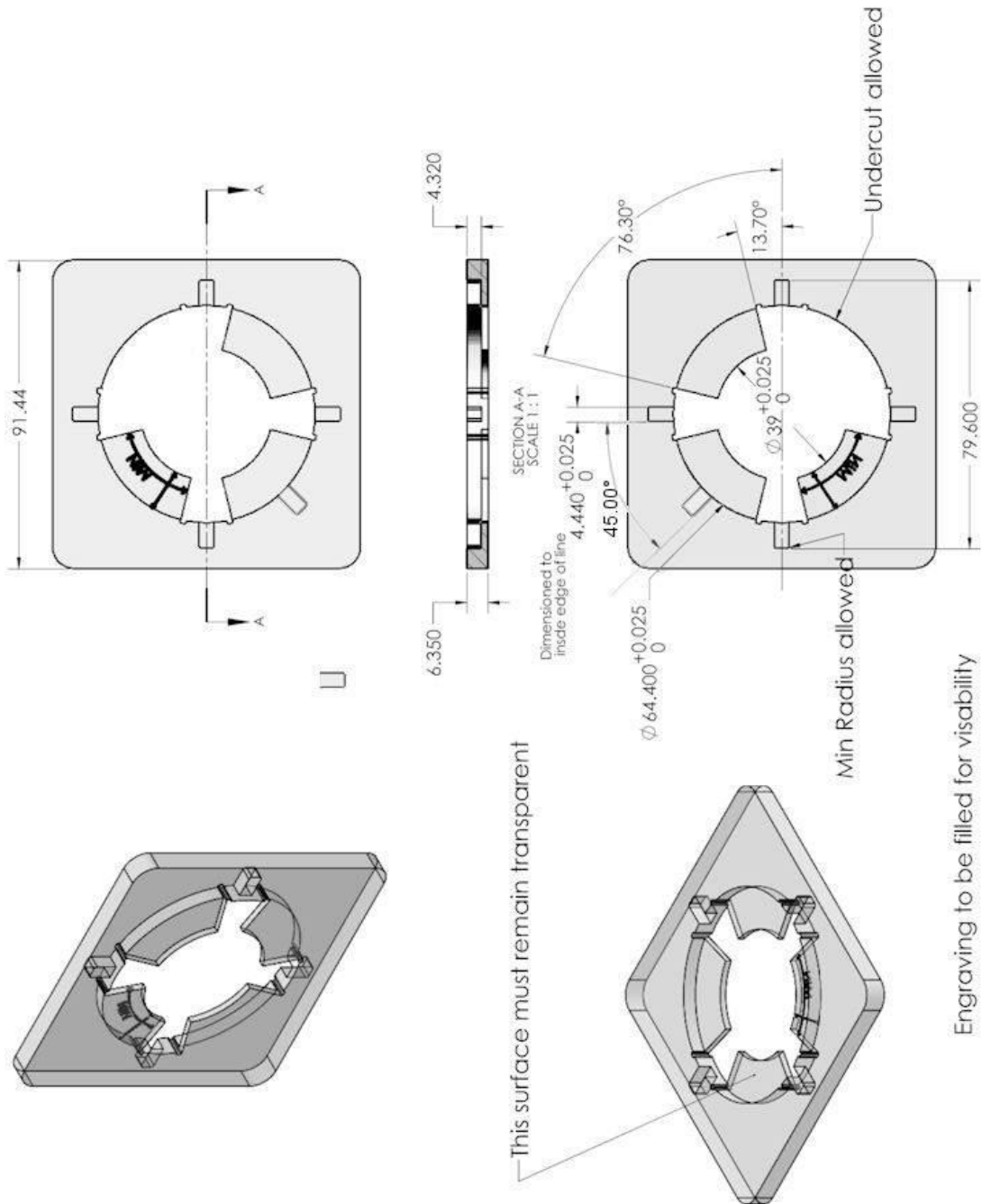


Figure A-8 Gauge M-EK01 Gauge for Module Electrical Keep Out Zone

### A.2.1.7 Gauge M-OD1

Figure A-9 defines gauge M-OD1.

Purpose: To check maximum diameter of the optical element.

Testing: Place gauge on a flat surface. Place test LED module containing optical element into gauge in a face-up orientation. If the test LED module freely seats into the gauge without obstruction or deformation of the module, then the module passes.

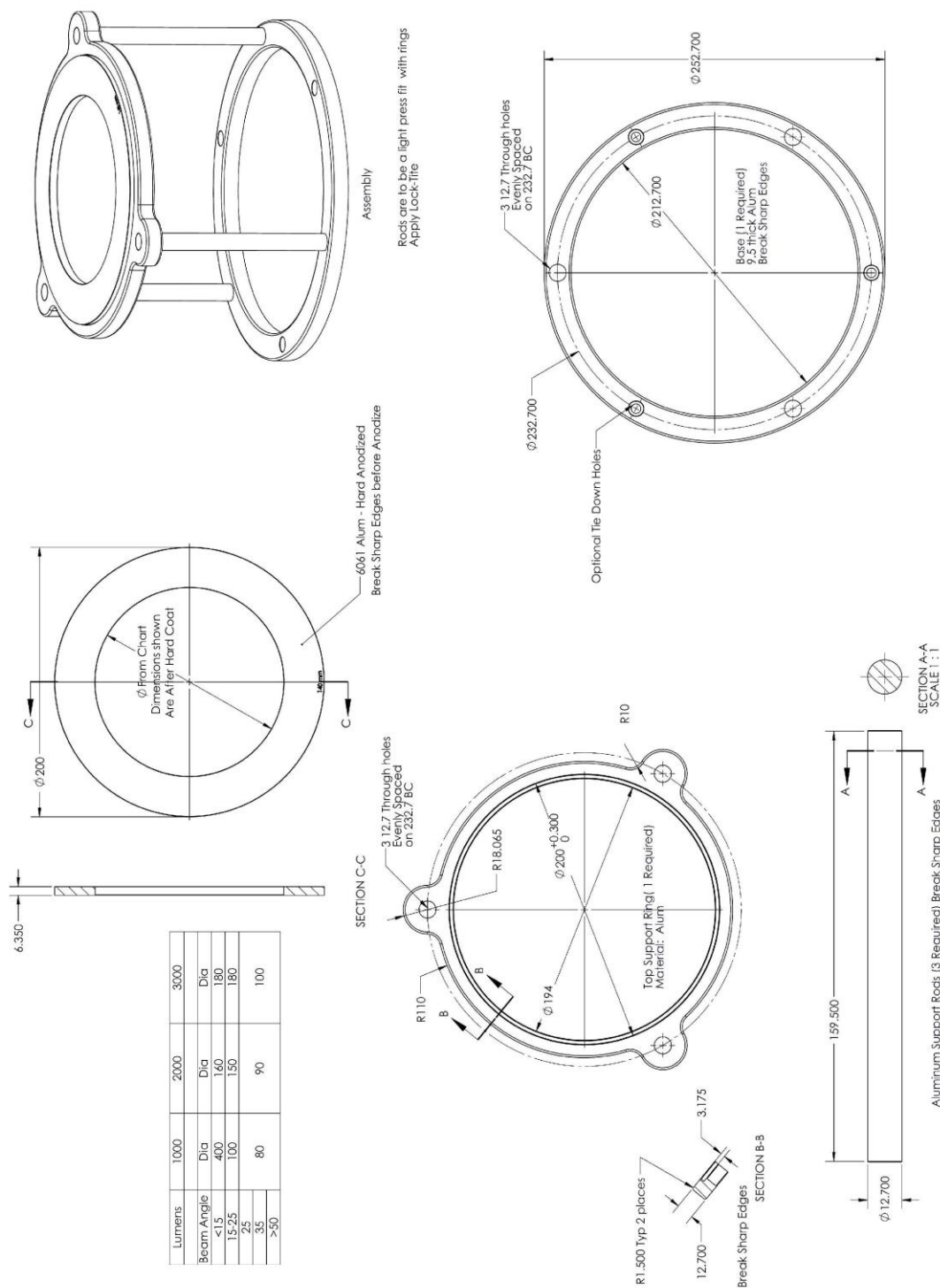


Figure A-9 Gauge M-OD1 Gauge for maximum diameter of the optical element.

## A.2.2 Tested parameters

Required Module Mechanical Dimensions:

“a” is measured in a compressed state, using vertical caliper and M-LT2 gauge as a reference plane.

“g” is measured in a compressed state, using vertical caliper and M-LT2 gauge as a reference plane.

“b” is measured in a compressed state, using vertical caliper and M-LT2 gauge as a reference plane.

“ $\emptyset h_1$ ” is measured using gauge M-LT1

“ $\emptyset h_2$ ” is measured using gauge M-EK01

“ $\emptyset d$ ” is measured with caliper or 3D measurement tool

“k” is measured with caliper or 3D measurement tool (preferred)

“J1” is measured with caliper or 3D measurement tool

“J2” is measured with caliper or 3D measurement tool

“ $\emptyset c$ ” is measured with caliper or 3D measurement tool

## A.2.3 Test result

The LLE under test passes if the verified dimensions are within the minimum and maximum limits defined in Section 3 and Section 4.2.

## A.3 Photometric testing

### A.3.1 Testing equipment

An integrating sphere-spectroradiometer system, 25 cm diameter minimum,  $2\pi$  geometry. If  $4\pi$  geometry is used, the sphere diameter should be at least 1m. This system shall be calibrated against spectral radiant flux standards traceable to an NMI.<sup>21</sup>

A goniophotometer system with measurement distance of at least 0,5 m. This system shall be calibrated against illuminance or luminous intensity standards traceable to an NMI.<sup>22</sup>

A Charge Coupled Device (CCD) based system to measure luminance with sufficient resolution to measure at least 500 pixels over the actual LES area.

### A.3.2 Test Setup and measurement operating conditions

In general, the light output of an LED Light Engine depends on the operating conditions. For example, the Luminous Flux depends on the thermal power generated by the LED Module and the temperature of the Thermal Interface Surface. This section defines the operating conditions that shall be applied for the

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<sup>21</sup> See [IES LM-79-08], Section 9.1 and sub Sections therein for additional information with respect to measurements with integrating sphere photometers. See also [CIE 84].

<sup>22</sup> See [IES LM-79-08], Section 9.3 and sub Sections therein for additional information with respect to measurements with goniophotometers. See also [CIE 121].

provisions for the optical interface as defined in Section 4. If the LLE is operated under different conditions, the optical properties of the LLE may differ from the provisions defined in Section 4.

If an LLE is operated under the conditions listed below, the LLE shall comply with the provisions in Section 4:

- The LED Module shall be mounted to a heat sink in a manner specified by the LLE manufacturer. Air movement affecting the temperature of the LLE shall be avoided. The mounting position of a Spot LED Module LLE is not considered to have a significant influence on the photometric properties and can thus be chosen arbitrarily.
- The Electronic Control Gear shall be mounted per LLE manufacturer specification from the LED Module at an ambient temperature of 25°C. All measurements shall be made with the LED module and ECG as described and recommended by the manufacturer.
- The heat sink shall either passively stabilize or actively regulate the  $t_{r,mod}$  temperature, as specified by the manufacturer, to be stable within the interval [ $t_{r,max} - 5^{\circ}\text{C}$ ,  $t_{r,max}$ ]. The stabilization criteria from [IEC/PAS 62717] shall apply. Wait until stabilization of the temperature  $t_r$  at the thermal interface. The temperature  $t_r$  is deemed stable if the difference between two consecutive temperature measurements, taken at least 15 min apart, is less than 0,5 % of the total temperature rise
- The optical output of the LLE shall not be affected in any way, by object(s)—reflectors, glass or plastic windows, heat sink features, etcetera—that are exterior to the LLE and heat sink.
- The measurement conditions specified in [IEC / PAS 62717], Annex A shall apply.
- In case the LLE consists of more than one LED Module, photometric properties shall be reported per LED module, not for the complete LLE.

### **A.3.3 Testing procedure Integrating Sphere**

- Mount the LED Module to a suitable heat sink. The LES shall be tightly connected to the opening of the integrating sphere by means of a suitable mechanical adapter. The ECG shall be mounted in due distance to the LED Module.
- Turn on the LLE.

Wait until the temperature at the  $t_r$  point is stable, as defined in Section A.3.2.

Perform the test as described in [IES LM-79-08], Section 9.1.

Data collected from this measurement are Luminous Flux and Spectral Power Distribution (SPD).

From SPD, calculate CCT according to CIE 13.3 and CRI simulating a color plate measurement according to [CIE 13.3]

This test may also be done during the thermal measurement described in Section A.4.2.3.

### **A.3.4 Testing Procedure Goniophotometer**

- Mount the LED Module to a suitable heat sink on the goniophotometer. The LES shall be open and not obscured by any objects, cables etc... The ECG shall be mounted in due distance to the LED Module.
- Turn on the LLE.

Wait until the temperature at the  $t_r$  point is stable, as defined in Section A.3.2. If no absolute Luminous Flux values are to be determined, the  $t_r$  temperature may differ from  $t_{r,max}$ .

Perform the test as described in [IES LM-79-08], Section 9.3 with C-slices every 15°, and azimuth angles at least every 5° for wide angle, beams with no significant beam structure. For medium flood or narrower beam patterns or systems with integrated optics and for beams with apparent beam structure, perform C-slices every 5° and azimuth angles in 0,5° resolution or the necessary resolution needed to fully resolve beam pattern structure.



**A.3.5 Testing procedure Luminance measurement**

- Perform a suitable geometrical calibration to relate the size of the luminance image to the geometrical dimension of the LES. This should be done at least after any modification of the test setup.
- Mount the LED Module on a suitable heat sink. The CCD shall measure the luminance directly looking at the LED Module along the symmetry axis.
- Choose the focus of the CCD camera to be in the plane of the OCA, not on the LEDs.
- Turn on the LLE.
- As only relative data is to be taken, it is not necessary to wait for thermal stabilization if the duration of the measurement is below 1 s. Otherwise, wait until the temperature at the  $t_r$  point is stable, as defined in section A.3.2.
- Measure the luminance image of the LED Module.
- For data evaluation, the image may be rotated by any degree or shifted by up to 1 mm in any direction.
- Determine the center of the luminance image. Shift the center of the evaluation (Figure 4-2) such that both coincide.
- Evaluate the average luminance  $L_i$  in each area  $A_i$  as defined in section 4.5. Note that the LES category diameter shall be taken for this evaluation. Rotate the crosshair by  $90^\circ$  in steps of  $1^\circ$ . For every step, evaluate the rotational symmetry parameter  $S$  as described in section 4.5. The maximum shall be taken as value for  $S$ .
- Determine the actual LES area as the minimum circle around the center of gravity of the luminance image that encircles all pixels with  $>5\%$  of the maximum  $L_i$  ( $i=1\dots5$ ).
- Evaluate the average luminance  $L_{avg}$  over the actual LES area.
- Calculate the RMS (root mean square) of the luminances  $L_j$  of every pixel  $j$  inside the LES:

$$L_{RMS} = \sqrt{\sum L_j^2 / N}$$

The number of pixels  $N$  shall not be less than 500. The uniformity parameter shall be calculated  $U = L_{avg} / L_{RMS}$ .

**A.3.6 Test result**

The LLE under test passes if all verified parameters are within the minimum and maximum limits defined for their rated category.

Parameters to be verified on the essentially lambertian LLE include:

LES diameter, as measured according to Section A.2.2, agrees with rated LES category according to Section 4.2

OCA category and LES category are compatible according to Section 4.2.2.

Measured Luminous Flux agrees with rated Flux category according to Section 4.3.1

Partial Luminous Flux for Flux Zones FC1, (FC2-FC1), (FC3-FC2), (FC4-FC3) is within defined limits (Section 4.4). Interpolation of goniophotometer data is allowed in this test.

Rotational symmetry of Luminous Intensity fulfills criterion defined in Section 4.4.

The measured uniformity parameter  $U$  deviates not more than -5 percentage points from rated Uniformity  $U$  (e.g. rated 70% allows for a minimum of 65%.)

Luminance Rotational Symmetry shall comply with the limits given in Section 4.5

Luminance Center Balance shall comply with the limits given in Section 4.5

Color coordinates agree with rated CCT category (Section 4.6)

CRI is not more than 3 units below rated CRI

A measurement procedure for LES height  $h_p$  will be defined in a later version of this specification.

Parameters to be verified on the non-essentially lambertian LLE include:

CBCP

Beam Angle

Total Flux

## A.4 Thermal testing

### A.4.1 Required Tools

#### A.4.1.1 Thermocouples

All thermal tests shall be conducted with thermocouples as specified in [UL 1598] Section 19.7 or in Annex K of [IEC 60598].

#### A.4.1.2 Thermal Interface Materials

This Book 5 directs that the TIM is part of the LLE<sup>23</sup>. However, if the test is being conducted using the TTE, then the TIM at TTE interface needs to be a thermal grease that has the thermal conductivity of 3,1 W/mK and a thermal impedance of 0,09 Ccm<sup>2</sup>/W which is applied in accordance with thermal grease manufacturer's recommendations (generally applied as a very thin, uniform layer across the LLE thermal surface.)

#### A.4.1.3 Test fixture TPTF - Book 5

Zhaga Book 1 Section 6.2.2 describes and explains the purpose for the Test Fixture TPTF. Figure A-10 illustrates the Test Fixture TPTF for Book 5 schematically. The thickness of the heat flow elements shall be such that a 1-dimensional heat flow through the heat flux sensor is achieved.

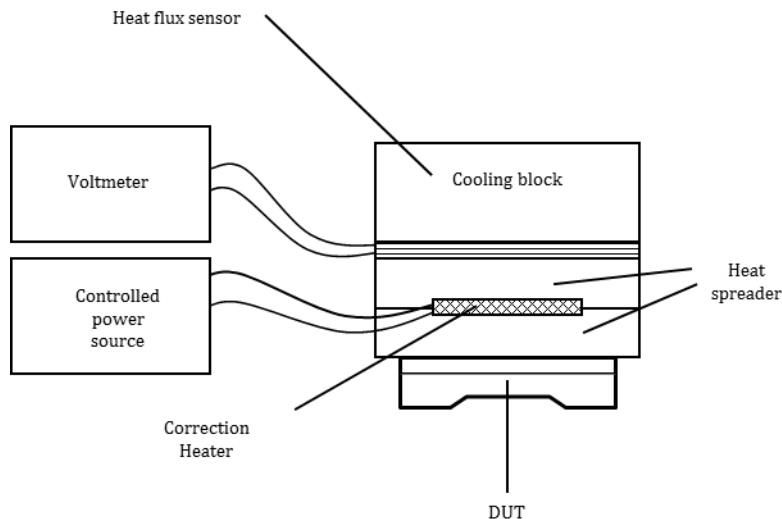


Figure A-10 Book 5 Test Fixture TPTF schematic illustration

<sup>23</sup> For testing purposes if the TIM is not part of the module, all tests with LLEs shall be conducted with an "average performance TIM". For an "average performance TIM", preferably silicone-based Keratherm 86/82 should be used. If not available, a comparable material with a thermal conductivity of 6,5 W/mK and thermal impedance of 35 Kmm<sup>2</sup>/W (determined according to [ASTM D5470]) may be taken.

The TPTF material shall be an Aluminum alloy with a thermal conductivity in the range 120-140 W/ mK.<sup>24</sup>

Figure A-11 shows the basic structure of the Test Fixture TPTF for Book 5.

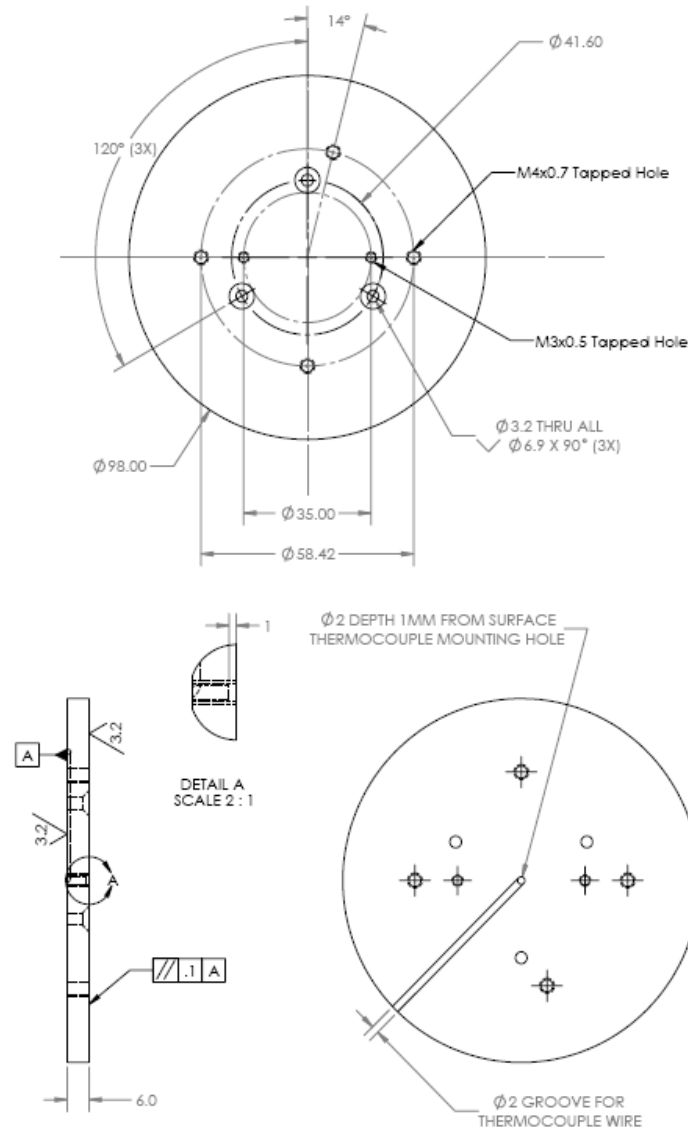


Figure A-11 Test Fixture TPTF for Book 5

#### A.4.1.4 Thermal Test Engine TTE - Book 5

Thermal Test Engine TTE for Book 5 is shown in Figure A-12. A Vishay LTO 100 heater is recommended to be used. If not available, another heater with sufficient power capability and heat transfer area of approximately 11,5 mm x 14 mm is to be used. The heater shall be in good thermal contact with the Luminaire under test, for example by use of thermal grease.

The TTE material shall be the same as for the TPTF defined in Annex A.4.1.3.

<sup>24</sup> During testing, AlCu4PbMg (EN AW-2007) was used. Other suitable materials include AlCu4Mg1 (EN AW-2024) and AlMg3 (EN AW-5754).

The TTE-Book 5 shall always be mounted with M3 screws, using a screw torque of 0,3 Nm.

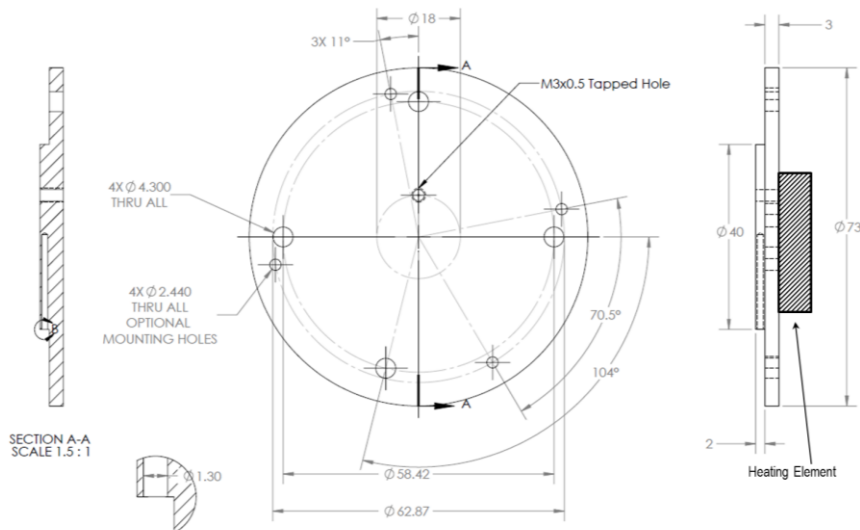


Figure A-12 Thermal Test Engine TTE for Book 5

## A.4.2 Thermal Power Testing

### A.4.2.1 Total thermal power

The purpose of this test is to verify that the total thermal power,  $P_{th}$ , produced by the LLE under test is within the specified limits.

$P_{th}$  can be determined by following equation:  $P_{th} = P_{el,mod} - P_{vis}$

where

$P_{el,mod}$  is determined by measuring the electrical input power of the LED Module

and

$P_{vis}$  is determined by measuring the spectral radiant flux. This can be done by evaluating the SPD measured during the photometric measurement in Section A.3.3. Usually, evaluating a wavelength range between 380 and 780 nm is sufficient. If the LLE emits significant radiation outside this range, the range may be extended.

### A.4.2.2 Thermal power through the thermal Interface

The purpose of this test is to verify that the thermal power,  $P_{th,rear}$ , produced by the LLE under test and directly transferred via the defined thermal interface to the Luminaire heat sink by heat conduction is within the specified limits.

### A.4.2.3 Combined thermal power test procedure

#### A.4.2.3.1 Required tools

Test Fixture TPTF for Book 5. It is recommended to shield the Test Fixture from air convection by a suitable isolation.

An integrating sphere-spectroradiometer system, 25 cm diameter minimum,  $2\pi$  geometry. This system shall be calibrated against spectral radiant flux standards traceable to a NMI.<sup>25</sup> The integrating sphere-spectroradiometer system can be separate from the TPTF-Book 5, with care to do measurements under comparable thermal conditions.

<sup>25</sup> See [IES LM-79-08], Section 9.1 and sub Sections therein for additional information with respect to measurements with integrating sphere photometers. See also [CIE 84].

**A.4.2.3.2 Test condition**

The Test Fixture TPTF for Book 5 shall regulate the temperature of the Thermal Interface Surface of the LLE under test to be within  $[(t_r - 5 \text{ K}), t_r]$  of the rated  $t_r$  temperature.

The optical output of the LLE shall not be affected in any way, by object(s) such as reflectors, glass or plastic windows, heat sink features, etcetera—that are exterior to the Book 5 module under test and Test Fixture TPTF-Book 5.

**A.4.2.3.3 Test procedure<sup>26</sup>****A.4.2.3.3.1 Measurement of  $P_{\text{vis}}$  for the LLE using integrating sphere**

- Attach the LLE via its mounting features to a fixture or cooling block that will keep the Thermal Interface Surface of the LLE under test to be within  $[(t_r - 5 \text{ K}), t_r]$  of the rated  $t_r$  temperature using an average thermal interface material as defined in A.4.1.2 if one is not specified by the manufacturer.
- Assemble the structure to the integrating sphere. The optical output of the LLE shall not be affected in any way by objects.
- Connect a power meter in between the separated control gear and the LLE<sup>27</sup>.
- Connect the separated control gear to mains power as appropriate for the LED Light Engine. Electrical parameter tolerances according to [IEC 62717], Annex A shall be applied.
- Turn on and wait for thermal stabilization of  $t_r$  at the thermal interface as described in Section A.3.2.
- Measure  $t_r$  temperature and check that  $t_r$  is within the interval  $[t_{r,\text{max}} - 5 \text{ K}, t_{r,\text{max}}]$
- Increase heating power of internal correction heater  $P_{\text{thCH}}$  until  $t_r$  criteria is fulfilled
- Measure radiant flux in an integrating sphere and calculate  $P_{\text{vis}}$  in [W].

**A.4.2.3.3.2 Measure electrical power  $P_{\text{el,mod}}$  to the LED Light Engine. Calibration of  $P_{\text{th,rear}}$  test setup**

This section specifies the calibration procedure of the Test fixture TPTF for Book 5. All testing is to be done with the DUT in the base up configuration (i.e. the light is being directed in the downwards direction)

Calibration shall be completed for every new LLE unless the LLE manufacturer has shown that the thermal path is unchanged within an LLE family (i.e. lumens, CRI, CCT)

- Attach the LED module to the Test fixture TPTF for Book 5
- Perform calibration as defined in Book 1 Section A.1.3.2.3
- Repeat the calibration steps with the internal correction heater configured to consume 20 W, 30 W, 40 W, 50 W, 60W, and 70W of electrical power, yielding  $V_{\text{HFS,TTE}}(20)$ ,  $V_{\text{HFS,TTE}}(30)$ ,  $V_{\text{HFS,TTE}}(40)$ ,  $V_{\text{HFS,TTE}}(50)$ ,  $V_{\text{HFS,TTE}}(60)$ , and  $V_{\text{HFS,TTE}}(70)$  respectively.

**A.4.2.3.3.3 Measurement of  $P_{\text{th,rear}}$  for the LLE**

- Attach the LLE via its mounting features to the Thermal Power Test Fixture (TPTF) using an average thermal interface material as defined in Section A.4.1.2 if one is not supplied. Figure A-13 shows this test setup.
- Perform  $P_{\text{th,rear}}$  measurements as defined in Book 1 Section A.1.3.2.4

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<sup>26</sup> This LLE test procedure is done near typical Luminaire ambient temperature of 25°C. If a Luminaire is to be operated at different ambient temperature, this LLE characterization stays valid, only Luminaire  $R_{\text{th}}$  will change.

<sup>27</sup> The LLE manufacturer should provide instructions to Test Labs on Request, which describe how to determine  $P_{\text{el,mod}}$  with a given LLE. These might also include a special test ECG.

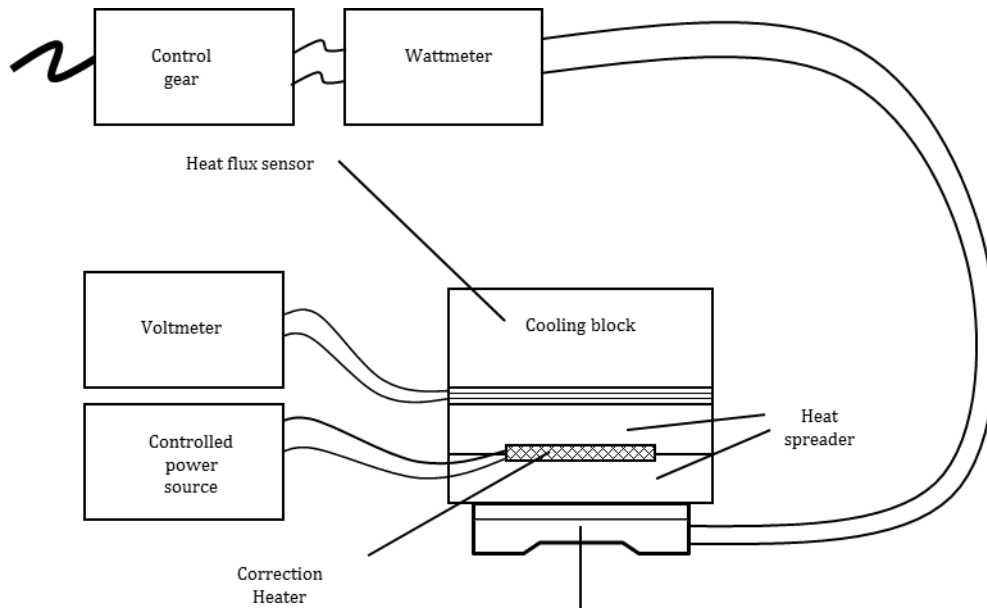


Figure A-13 Test setup for  $P_{th,rear}$  measurement

#### A.4.2.3.4 Test results

The LLE under test passes if the following conditions are fulfilled:

The measured total thermal power,  $P_{th}$ , does not exceed the rated maximum thermal power  $P_{th,max}$  as given in the LLE manufacturer's product data sheet (cf. Annex C) by more than 5%.

The measured thermal power conducted through the thermal interface  $P_{th,rear}$ , does not exceed the rated maximum thermal power values  $P_{th,rear,max}$  as given in the LLE product data sheet by more than 5%

### A.4.3 Thermal Uniformity Testing

#### A.4.3.1 Thermal Uniformity Testing of LLE

The purpose of this test is to make sure that the LLE has sufficient internal means to spread the heat generated by the LED packages to be represented by the Thermal Test Engine TTE for Book 5. In case significant differences are measured, a correction term is calculated as defined in this Section.

#### A.4.3.2 Required tools

Test Fixture TUTF for Book 5 specifications:

The material shall be an Aluminum alloy with a thermal conductivity in the range 120-140 W/ mK.<sup>28</sup>

Thickness shall be 4 +/- 0,1 mm at the Thermal Interface Surface of the Test Fixture. The Thermal Interface Surface shall have a surface planarity smaller than 0,1 mm and a surface roughness smaller than 3,2  $\mu$ m.

At the center and at the 4 points  $t_{S1}...t_{S4}$  indicated in Figure A-14 thermocouples shall be placed and fixed with tight thermal contact at the end of the holes. The thermocouple wires may be placed in a slit at the backside that shall be in the axial direction not to hinder heat flow.

<sup>28</sup> During testing, AlCu4PbMg (EN AW-2007) was used. Other suitable materials include AlCu4Mg1 (EN AW-2024) and AlMg3 (EN AW-5754).



## Annex B Holder Compliance Testing (Normative)

### B.1 General

All tests defined in this Annex shall be performed on 1 specimen of a holder.

### B.2 Mechanical interface tests

#### B.2.1 Testing equipment

The mechanical dimensions shall be tested with gauges H-H5a, H-H5b and H-KO1. Measurement accuracy of better than +/- 0,05 mm shall be achieved.

#### B.2.2 Tested parameters

All mechanical dimensions specified in below shall be verified at an ambient temperature of 25°C ± 5°C.

Holder Mechanical Dimensions

“h5” to be measured with gauges H-H5a and H-H5b

“h6[1]” to be measured with gauge H-KO1

“h7[2]” to be measured with gauge H-KO1

“h8” to be measured with gauge H-KO1

“h10” to be measured with gauge H-KO1

“h11” to be measured with gauge H-KO1

“h12” to be measured with gauge H-KO1

“F” to be measured with gauge H-KO1

“X3” is measured with caliper or 3D measurement tool

#### B.2.3 Test result

The Holder under test passes if the applicable dimensions are verified using the appropriate gauges.



## **Annex C Luminaire Compliance testing (Normative)**

### **C.1 General**

All tests defined in this Annex shall be performed using 1 specimen of a compliant Socketable LLE. In case the Luminaire is intended to be used with more than one LLE/LED Module, the appropriate number of Thermal Test Engines TTE for Book 5 are to be used for the thermal interface tests. Luminaire shall be measured with all accessories, including holder. Manufacturer submission shall clearly document condition of luminaire and method of test (which meets all previous defined limitations.)

### **C.2 Mechanical interface tests**

#### **C.2.1 Testing equipment**

The mechanical dimensions shall be tested with a hand gauge or (semi-)automated 3D measuring equipment. Measurement accuracy of better than +/- 0,05 mm shall be achieved. See Annex B for additional testing or reference to the holder verification. For measurements of surface planarity and roughness, use equipment capable of measuring dimensions as defined in Sections 3.6 and 3.8.

#### **C.2.2 Tested parameters**

All mechanical conditions specified in Section 3.6 and 3.8 and dimensions of an integrated holder, if any, specified in Section B.2.2 shall be verified at an ambient temperature of  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ .

#### **C.2.3 Test result**

The Luminaire under test passes if the applicable dimensions are verified.

### **C.3 Electrical interface tests**

The electrical interface of a Luminaire is identical to the electrical interface of the LLE. Thus, no electrical interface tests are to be performed.

### **C.4 Thermal interface test**

#### **C.4.1 Thermal Resistance of Luminaire heat sink**

The purpose of this test is to verify the rated thermal resistance(s)  $R_{th}$  of the Luminaire under test.

##### **C.4.1.1 Required tools**

Thermal Test Engine TTE – Book 5.

If the test is being conducted using the TTE, then the “TIM” needs to be a thermal grease that has the thermal conductivity of 3.1 W/mK and a thermal impedance of 0,09  $\text{Ccm}^2/\text{W}$ .

##### **C.4.1.2 Test conditions**

The Luminaire shall be mounted in a draught free room, with an orientation that is according to the “intended use” as indicated in the product data sheet of the Luminaire under test. The ambient air temperature in the room, at a distance of  $25 \pm 5$  mm from the edge of the Luminaire at the height of the Thermal Interface Surface, shall be  $25 \pm 5$  °C. If the Luminaire is not positioned horizontally, the ambient air temperature shall be determined at the lowest point that satisfies the above distance requirement.

If multiple LLEs are used within one luminaire, all LED modules shall be replaced with an individual TTE-Book 5. All TTE-Book 5 shall be operated at thermal power corresponding to the LLE’s intended to be used, even if only one position is to be tested at a time.

**C.4.1.3 Test procedure**

Assemble the Thermal Test Engine TTE-Book 5 into the Luminaire under test and the specified TIM for the TTE-Book 5.

Configure the Thermal Test Engine TTE-Book 5 to generate 10W of electrical power

Wait until the temperature  $t_{r,TTE}$  at the Thermal Interface Surface of the TTE-Book 5 is stable. The temperature  $t_{r,TTE}$  shall be deemed stable if the difference between two consecutive temperature measurements, taken at least 15 min apart, is less than 0,5% of the absolute temperature rise

- Measure and record the temperature  $t_{r,TTE}$ .
- Calculate the thermal resistance as

$$R_{th(10W)} = (t_{r,TTE} - t_a) / P_{th}$$

where  $P_{th}$  is the thermal power generated in Thermal Test Engine TTE-Book 5 (equal to electrical power) and  $t_a$  is the temperature of the ambient air.

- Repeat the procedure with the Thermal Test Engine TTE-Book 5 configured to consume 20W, 30W, 40W 50W, 60W and 70W of electrical power, yielding in  $R_{th(20W)}$ ,  $R_{th(30W)}$ ,  $R_{th(40W)}$ ,  $R_{th(50W)}$ ,  $R_{th(60W)}$ ,  $R_{th(70W)}$ . If the luminaire is intended to operate in a limited power range, parts of this test may be skipped and the limited power range needs to be marked in the product data sheet.

**C.4.1.4 Test result**

The Luminaire under test passes if the measured  $R_{th}$  does not exceed the rated  $R_{th}$  by more than 5% for all stated power levels.

## Annex D Product data sheet requirements (Normative)

### D.1 LLE Marking

In addition to the marking requirements imposed by national or international standards, the following marking shall be done on the product or in the accompanying documentation (note: these are minimum requirements and are required):

#### D.1.1 Essentially Lambertian LED module and ECG

Match Product Data Sets as defined in Book 1.

#### D.1.2 Non-Essentially Lambertian LED module and ECG

Match Product Data Sets as defined in Book 1.

Include the beam angle and corresponding category per Section 4.4.

### D.2 Luminaire marking

In addition to the marking requirements imposed by national or international standards, the following information shall be given in the product data sheet:

- The rated values of the Luminaire thermal resistance  $R_{th}$  for all declared LLE power levels in steps of 10 W.
- Number of LLEs or LED modules if greater than 1.
- ECG Type designation.

## **Annex E Safety (Informative)**

### **E.1 General**

This Specification of a Socketable spot LED Light Engine with Separate Electronic Control Gear shall ensure interchangeability of LED Light Engines. Safety issues are not assessed nor checked in the certification procedure. LLE and Luminaire manufacturers are responsible for safety of their products.

### **E.2 LED module**

Safety provisions with respect to a LED Module comprise, amongst others, [IEC 62031].

### **E.3 Electronic control gear**

Safety provisions with respect to an ECG comprise, amongst others, [IEC 61347-1] and [IEC 61347-2-13].

### **E.4 Luminaire requirements**

Safety provisions with respect to a Luminaire/LLE comprise, amongst others, [IEC 60598].

## **Annex F History of Changes**

<b>Location</b>	<b>Old</b>	<b>New</b>	<b>Reason</b>

**Table F-1 Revision History**

Book 5 Edition 1.2 is the first edition for public use and Table F-1 is empty.