IEC PAS 63328

Edition 1.0 2020-10

PUBLICLY AVAILABLE SPECIFICATION

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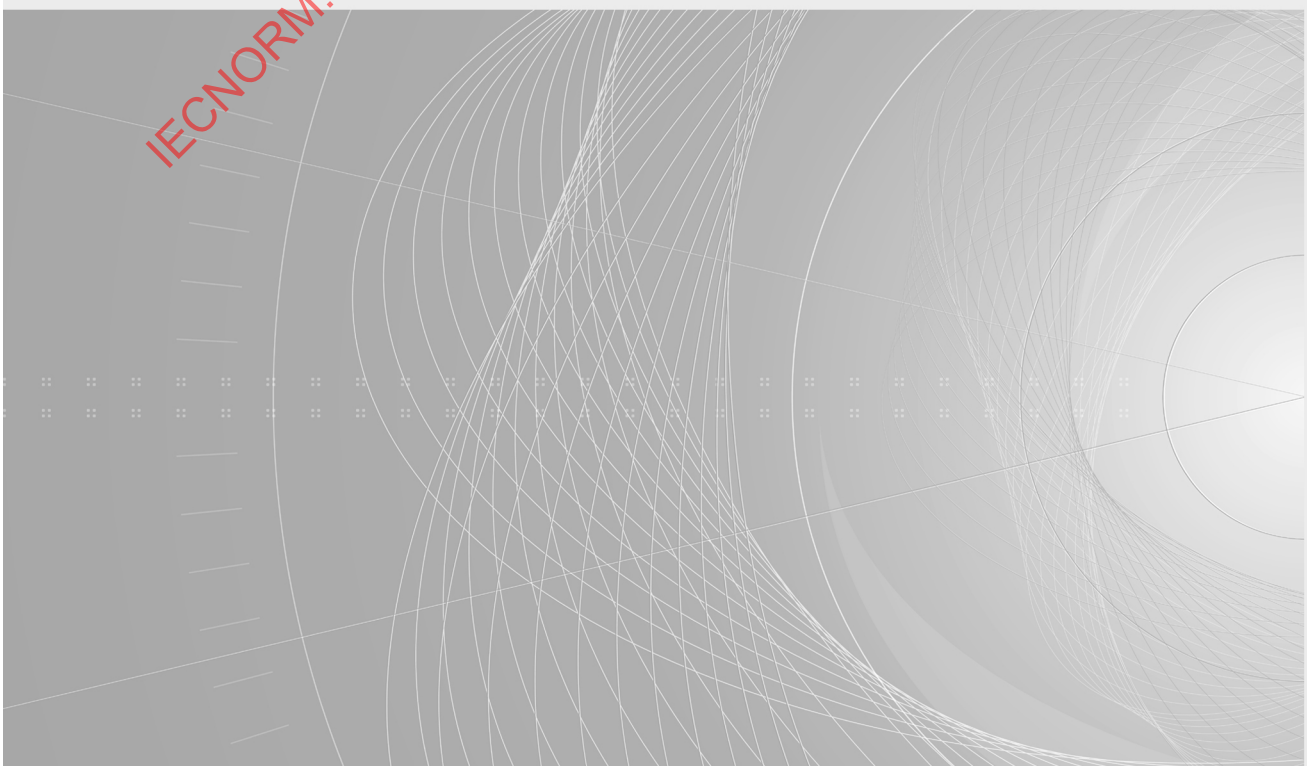
Zhaga interface specification Book 1 and Book 12



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ZHAGA INTERFACE SPECIFICATION BOOK 1 AND BOOK 12

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IEC PAS 63328 has been processed by subcommittee 34A: Electric light sources, of IEC technical committee 34: Lighting.

The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document
Draft PAS	**Report on voting**
34A/2195/DPAS	34A/2205/RVDPAS

Following publication of this PAS, which is a pre-standard publication, the technical committee or subcommittee concerned may transform it into an International Standard.

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INTRODUCTION

This PAS is a reproduction of Zhaga Book 1 Edition 1.8 and Book 12 Edition 1.2 with no changes introduced.

The document layout, terms and definitions, etc within this PAS therefore do not follow the normal IEC drafting rules that would be applied for an International Standard.

Subdivision 1 comprises Zhaga Book 12 Edition 1.2 – Rectangular LED arrays with circular LES and corresponding holders.

Subdivision 2 comprises Zhaga Book 1 Edition 1.8 – Overview and common information, which is essential to the interpretation of Zhaga Book 12 (and future Zhaga books).

The future intention is for the content of this PAS to be incorporated within one or more International Standards and at this time any conflict with IEC Directives and drafting rules will be addressed.

Subdivision 1

Zhaga Interface Specification Book 12

Summary (informative)

Background

The Zhaga Consortium is a global lighting-industry organization that aims to standardize components of LED luminaires, including LED light engines, LED modules, LED arrays, holders, electronic control gear (LED drivers) and connectivity fit systems.

Zhaga has created a set of interface specifications, known as Books. Each Book defines one or more components of an LED luminaire by means of the mechanical, photometric, electrical, thermal, and control interfaces of the component to its environment. This makes such products interchangeable in the sense that it is easy to replace one product with another, even if they have been made by different manufacturers.

Contents

This Book 12 defines LED arrays with a rectangular shape and a circular light emitting surface. For each LED array, this Book 12 also defines the mechanical interface between the LED array and the corresponding holder. The mechanical interface between the holder and the luminaire is defined in another Zhaga book.

This book should be read together with Zhaga Book 1.

Intended Use

The LED arrays defined in this specification are intended to be mounted on a heat sink by means of a holder and to be connected to a separate electronic control gear. The light output is essentially Lambertian to enable the luminaire optics to shape the application's desired light distribution from a defined input.

The LED arrays and holders defined in this Book 12 are intended to be installed and replaced by luminaire manufacturers only.

1 General

1.1 Introduction

The Zhaga Consortium is a global organization that aims to standardize components of LED Luminaires. A LED Luminaire is a lighting fixture for general lighting that contains a light source based on solid-state technology. Such light sources, including LED Modules and LED Light Engines, typically consist of one or more LEDs combined with an Electronic Control Gear (LED driver). Other components of LED Luminaires include LED Arrays, Holders, and connectivity fit systems.

Zhaga has created a set of interface specifications, known as Books, which define the interfaces between a component and its environment. Book 1 is a special Book in the sense that it provides common information, which is relevant to all other Books in the series. In addition, Book 1 defines requirements and compliance tests, which are applicable across multiple Zhaga books. Such Books refer to those requirements and compliance tests as applicable.

1.2 Scope

This Book 12 defines LED Arrays with a rectangular shape and a circular light emitting surface. For each LED Array, this Book 12 also defines the mechanical interface between the LED Array and the corresponding Holder. The mechanical interface between the Holder and the Luminaire (e.g. outline, OCA and mounting holes) is defined in [Book-10].

The LED Arrays defined in this specification are intended to be mounted on a heat sink by means of a Holder and to be connected to a separate Electronic Control Gear. The light output is essentially Lambertian to enable the Luminaire Optics to shape the application's desired light distribution from a defined input. The LED Arrays and Holders defined in this Book 12 are intended to be installed and replaced by Luminaire manufacturers only.

Although this Book 12 has been developed with "Chip-on-board" in mind, the specification is in no way limited to this technology.

1.3 Conformance and references

1.3.1 Conformance

All provisions in the Zhaga interface Specifications are mandatory, unless specifically indicated as recommended, optional or informative. Verbal expressions of provisions in the Zhaga interface specifications follow the rules provided in Clause 7 of ISO/IEC Directives, Part 2:2018. For clarity, the word "shall" indicates a requirement that is to be followed strictly in order to conform to the Zhaga interface specifications, and from which no deviation is permitted. The word "should" indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

1.3.2 References

For references which are not listed in this section, see [Book 1]. For undated references, the most recently published edition applies.

[Book 1] Zhaga Interface Specification, Book 1: Overview and Common Information.

[Book 10] Zhaga Interface Specification, Book 10: Circular LED modules for spot lighting.

1.4 Definitions

This section defines terms that have a specific meaning in the context of this Book 12. Terms that have a specific meaning across all Zhaga Books are defined in [Book 1].

LED Array	A light source that is supplied as a single unit and intended to be used in combination with a Holder to build a LED Module. In addition to one or more LEDs, their mechanical support and their electrical connection, it may contain components to improve its photometric, thermal, mechanical and electrical properties, but it does not include the Electronic Control Gear.
Book-12 LED Array	LED Array according to the specifications in this book.
Book-12 Holder	Holder according to the specifications in this book.

1.5 Acronyms

Acronyms that have a specific meaning across all Zhaga Books are defined in [Book 1].

1.6 Symbols

This section defines symbols that have a specific meaning in the context of this Book 12. Symbols that have a specific meaning across all Zhaga Books are defined in [Book 1].

L_i Average Luminance in Area i (unit: cd/m²)

S Luminance rotational symmetry

U Luminance uniformity

B Luminance center balance

1.7 Conventions

This section defines the notations and conventions used in the Zhaga Interface Specifications.

1.7.1 Precedence

In the case of any perceived discrepancy between the definitions provided in Part 1 of this document, Interface Definition and the definitions provided in Part 2 of this document, Compliance Testing, the definitions provided in Part 2 take precedence over the definitions provided in Part 1.

1.7.2 Cross references

Unless indicated otherwise, cross references to sections include the sub sections contained therein.

1.7.3 Informative text

Informative text is set in italics, unless the whole section is marked as informative.

1.7.4 Terms in capitals

Terms that have a specific meaning in the context of this Book 12 are capitalized. See section 1.4.

1.7.5 Units of physical quantities

Physical quantities are expressed in units of the International System of Units. All lengths that omit an explicit unit indication are in millimeters.

1.7.6 Decimal separator

The decimal separator is a comma.

1.7.7 Limits

Values that are indicated as typical, as well as values between parentheses, are informative.

2 Overview (Informative)

2.1 General

General information with respect to the Zhaga Interface Specifications and certification of products that comply with this Book 12 can be found in [Book 1], section 2.

2.2 Description of the LED Array and the Holder

This Book 12 defines LED Arrays and corresponding Holders typically applied in spot lighting applications. The LED Array in combination with a Holder is to be mounted to or into a Luminaire by an OEM Luminaire manufacturer typically by means of screws.

The LED Array defined in this Book 12 has a circular Light Emitting Surface. Figure 2-1 shows informative 3D-drawings of the LED Array and the Holder.

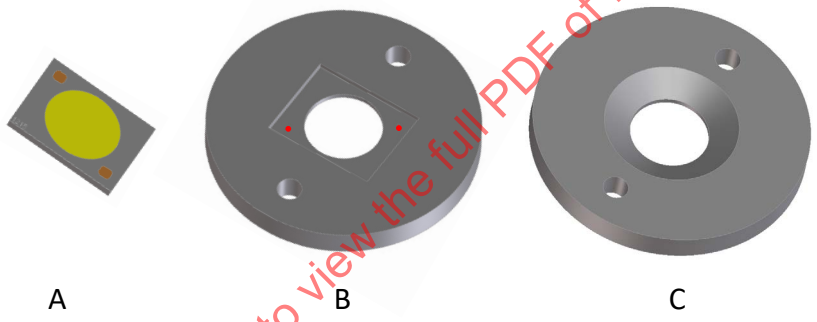

Figure 2-1 – 3D-drawings of a Book 12 LED Array and Holder (informative)

A: LED Array with LES and contact areas

B: Holder – bottom-side with cavity for the LED Array and contacts

C: Holder – top-side

The LED Array has two designators:

- The LED Array category according to the definition in this Book 12. This designator determines the form factor of the LED Array.
- The LES category according to [Book 1]. This designator determines the size of the LES.

The Holder also has two designators:

- The LED Array category according to the definition in this Book 12. This designator determines the form factor of the cavity for the LED Array.
- The maximum LES category according to [Book 1]. This designator determines the size of the opening for the LES.

This book 12 defines all Zhaga related parameters of the LED Array. Moreover, this book 12 defines the mechanical aspects of the Holder that relate to the interface to the LED Array (e.g. cavity and contact areas). The mechanical interface between the Holder and the Luminaire (e.g. outline, OCA and mounting holes) is defined in [Book 10].

The light output of the LED Array itself does not have a ‘spot light’ distribution but a general distribution (defined in section 4) which can be tailored into a specific distribution by means of Luminaire Optics. The photometric interface of the LED Array is specified here in such a way that using suitable Luminaire Optics, similar Luminaire performance in spot applications is to be expected using different LED Arrays with the same LES category. The specification has been carefully evaluated to yield as similar performance as possible without restricting the inner structure of the LED Array or the LED technology used inside. This has been done to leave as much room as possible for technical innovation on this field.

2.3 Outline of this Book

This Book 12 consists of two parts:

Part 1, Interface Definition, defines the LED Array and Holder interfaces to their environments:

- The mechanical interface (section 3).
- The photometric interface (section 4).
- The electrical interface (section 5).
- The thermal interface (section 6).

Part 2, Compliance Tests, defines:

- Compliance test tools, which are used for testing compliance of a LED Array or a Holder (section 7).
- The LED Array compliance tests (section 8).
- Holder Compliance tests (section 9).

The Annexes to this Book 12 provide the following additional information:

- Requirements on the information that shall be part of the Product Data Set of the LED Array and the Holder (Annex A).
- Definition of the cavity outline and mechanical reference of the Holder (Annex B).
- Guidelines for LES and Luminance measurements (Annex C).
- History of changes (Annex D).

Part 1: Interface Definition

3 Mechanical interface

For the purpose of this section, the provisions in [Book 1] – section 3.3, apply. The drawings in this section are not to scale.

3.1 Drawing principles

For the purpose of this section, the provisions in [Book 1] – section 3.1, apply.

3.2 Mechanical references and definitions

The reference plane and the reference point of a LED Array are defined in Figure 3-1. Dimensions are specified relative to either the reference point or the reference plane unless indicated otherwise.

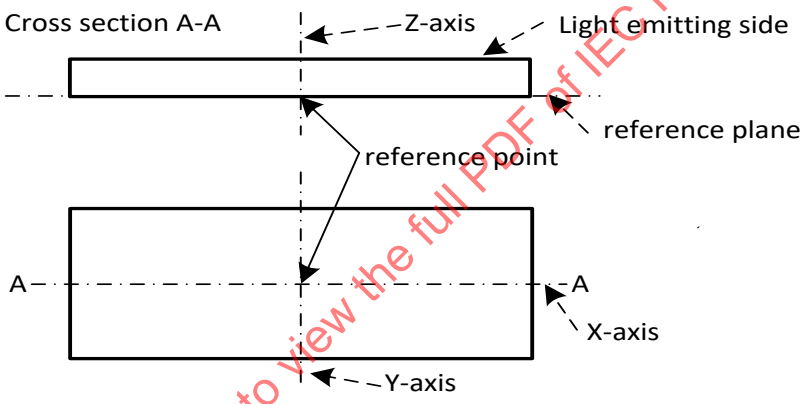

Figure 3-1 – Positions of the reference point and the reference plane of the LED Array

3.3 Mechanical interface of the LED Array

This Zhaga Book 12 defines seven LED Array categories identified by a designation. For each of these categories, this Book 12 defines:

- The outline of the LED Array.
- The position and size of the minimum contact areas.
- The position and size of the minimum mounting holes or so-called mouse bites. These mounting holes or mouse bites are optional but if they are present, they shall comply with the specifications in this book.
- The height of the PCB.

A Book 12 LED Array features an LES that fits a specific LES category as defined in [Book 1]. For each combination of a LED Array category and a LES category, this Book 12 defines:

- The keep-in zone ($Ø_{keep\text{-}in}$) being the area on the PCB where components are allowed.
- The position and size of the maximum contact areas.

3.3.1 Mechanical references for a LED Array

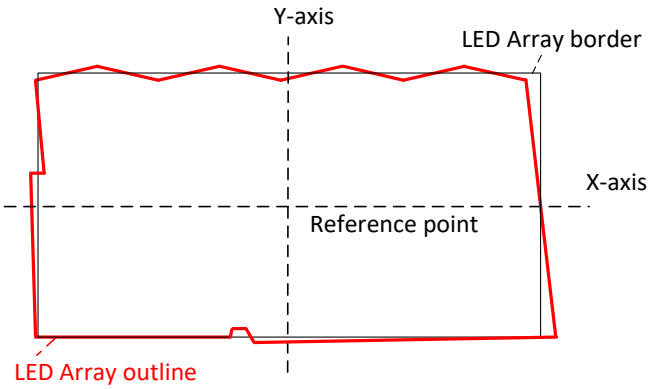

Figure 3-2 – Definition of the LED Array Border and mechanical references

By way of example, the red shape in Figure 3-2 indicates the outline of a Book 12 LED Array. By definition, the LED Array border is the rectangle that fits the LED Array outline such that the average deviation between LED Array outline and LED Array border is minimal[1]. Also by definition, both the X-axis and the Y-axis are axes of symmetry of the LED Array border. The mechanical reference point is where the X-axis and the Y-axis cross.

3.3.2 Dimensions depending on the LED Array category

3.3.2.1 Outline of the LED Array without mounting holes and without mouse bites

The mounting holes of a Book 12 LED Array are optional. In case the LED Array does neither feature mounting holes nor mouse bites, the outline of the LED Array shall comply with the requirements defined in this section.

1 In case of a LED Array with mouse bites, the area of these mouse bites shall be ignored while determining the mechanical references according to this definition.

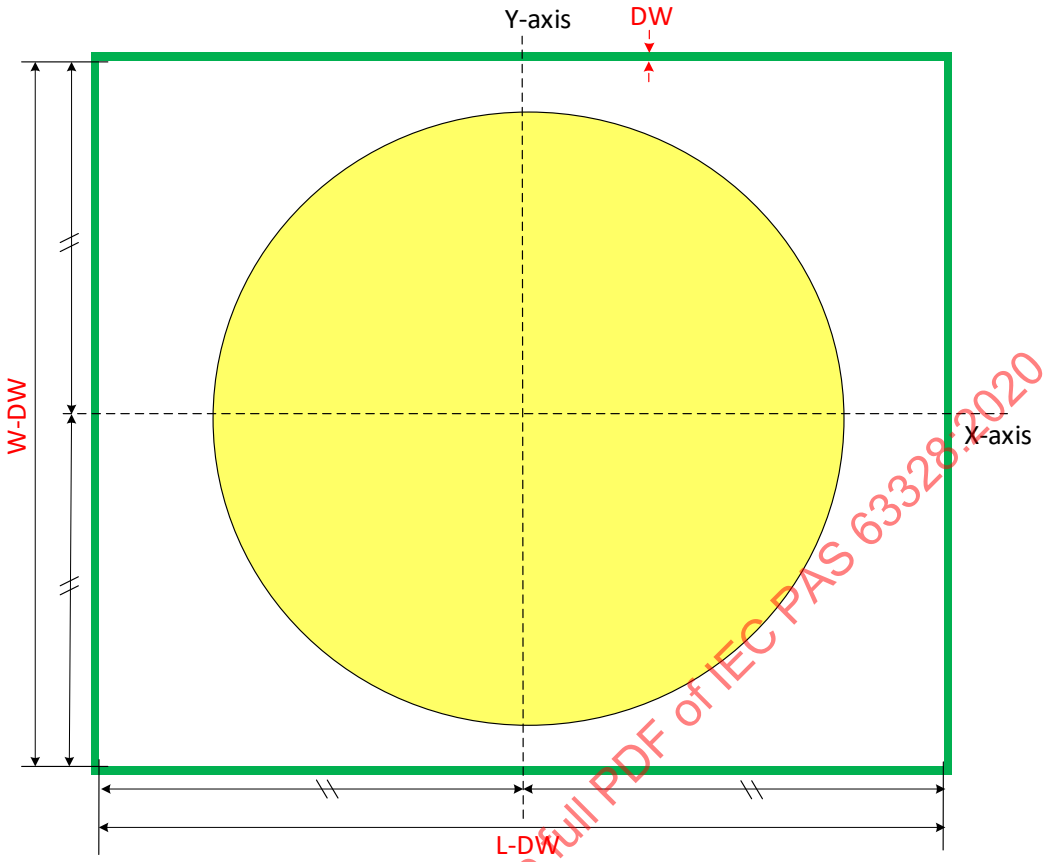

Figure 3-3 – Demarcation model for the outline of the LED Array without mounting holes and without mouse bites

The outline of the LED Array shall be in the demarcation zone indicated by the green area in Figure 3-3.

The reference X-axis and Y-axis are axes of symmetry of dimensions L and W. For each Book 12 LED Array category the values of the dimensions are listed in Table 3-1.

3.3.2.2 Mounting holes and outline of the LED Array in the C28x28 and C24x24 categories with mounting holes

The mounting holes of a Book 12 LED Array are optional. In case of a LED Array in one of the categories C28x28 or C24x24 that does feature mounting holes, the outline of the LED Array and the mounting holes shall comply with the requirements defined in this section.

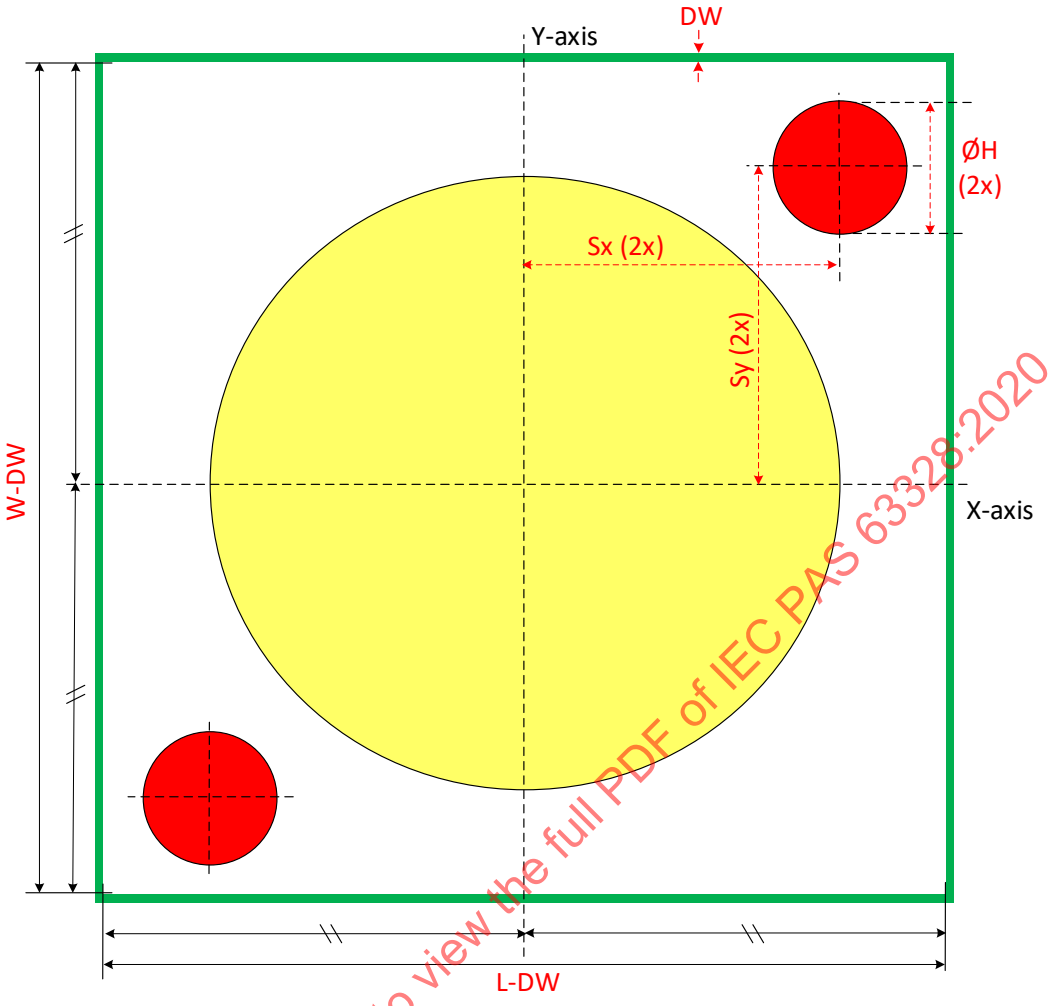

Figure 3-4 – Demarcation model – top view for the outline and mounting holes of the LED Array in one of the categories C28x28 or C24x24

The outline of the LED Array shall be in the demarcation zone indicated by the green area in Figure 3-4. At the same time the LED Array shall not overlap with the zones for the mounting holes in the demarcation model indicated by the red areas in Figure 3-4[2]. For each Book 12 LED Array category the values of the dimensions are listed in Table 3-1.

3.3.2.3 Outline of the LED Array in the C20x24, C19x19, C16x19, C13.5x13.5 and C12x15 categories with mouse bites

The mouse bites of a Book 12 LED Array are optional. In case of a LED Array in one of the categories C20x24, C19x19, C16x19, C13.5x13.5 or C12x15 that does feature mouse bites, the outline of the LED Array shall comply with the requirements defined in this section.

2 In this demarcation model, the minimum diameter of the mounting holes at nominal position is specified. In typical designs the diameter of these holes will be larger allowing for a tolerance on the position of the holes.

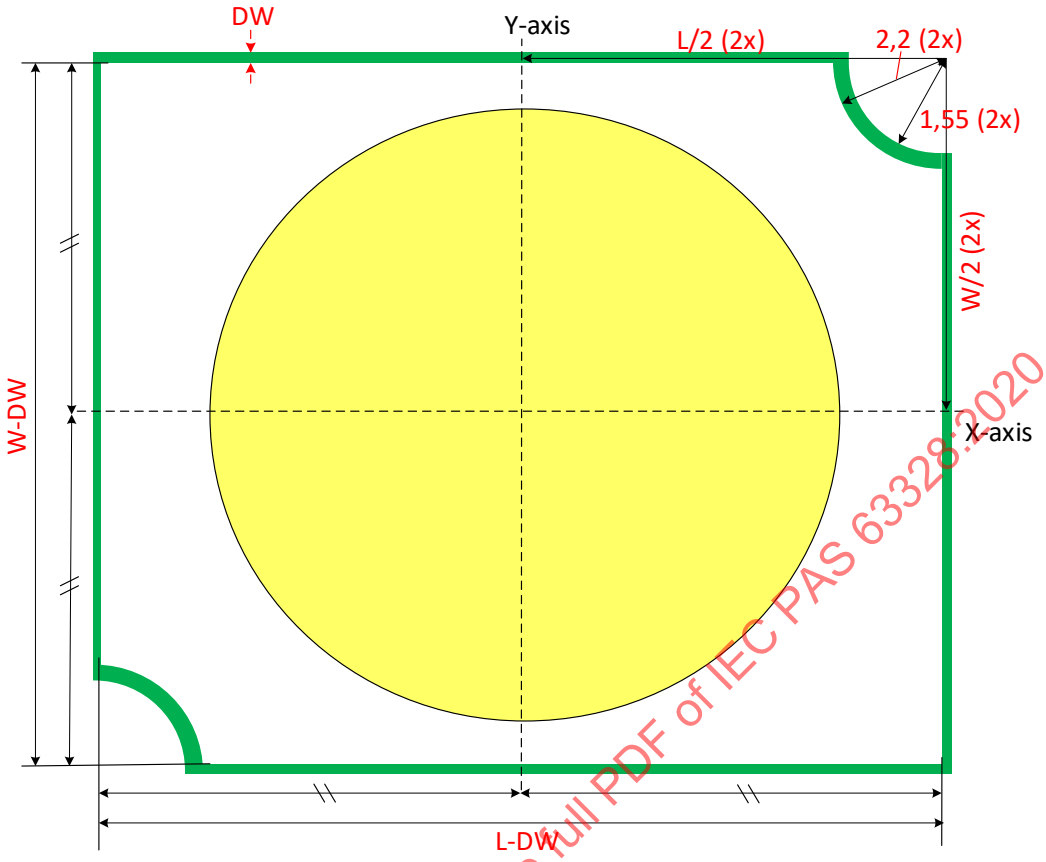

Figure 3-5 – Demarcation model – top view for the outline of the LED Array with mouse bites in one of the categories C20x24, C19x19, C16x19, C13.5x13.5 or C12x15

The outline of the LED Array shall be in the demarcation zone indicated by the green area in Figure 3-5. For each Book 12 LED Array category the values of the dimensions are listed in Table 3-1. As depicted in Figure 3-5, this definition results in LED Arrays having recesses in two corners.

3.3.2.4 Minimum electrical contact area for the (+) and (-) contacts

The Definition of the electrical contact area for the (+) and (-) contacts of the LED Array is depicted in Figure 3-6 with parameter values as listed in and Table 3-1.

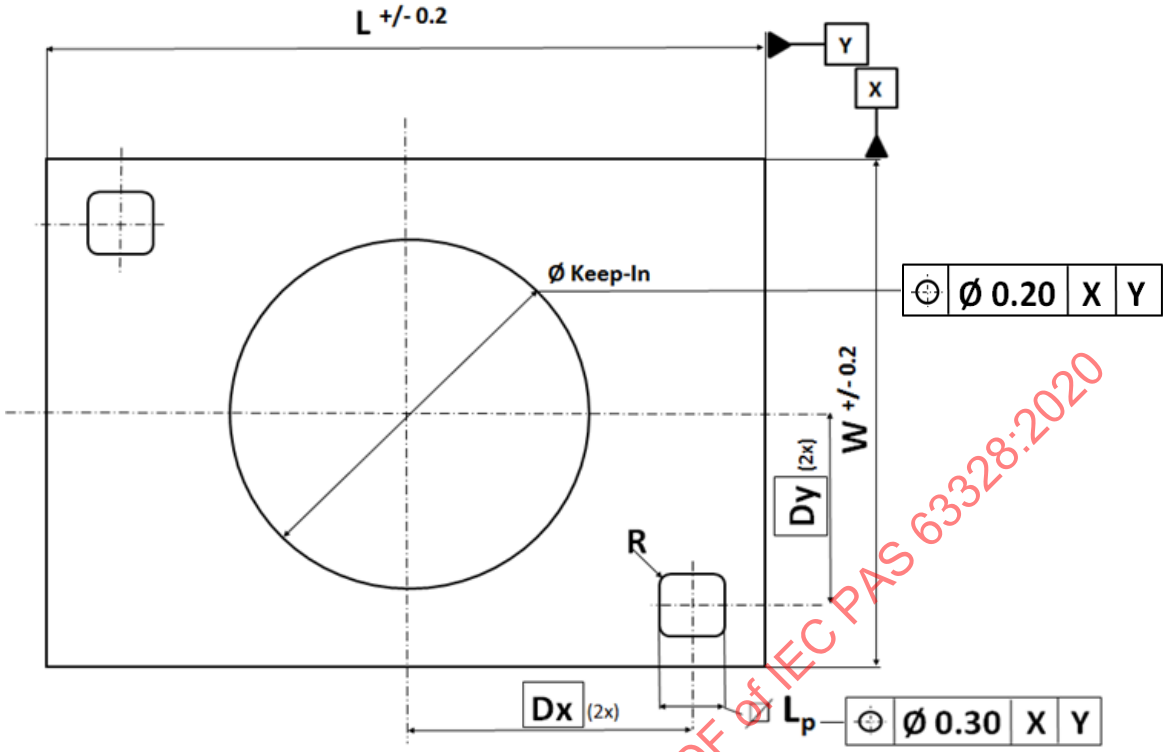

Figure 3-6 – Definition of the minimum electrical contact area for the (+) and (-) contacts – top view

This definition of the electrical contact areas of the LED Array can be translated into two requirements to be tested:

Requirement 1: the contact areas of the LED Array shall at least cover the round cornered square as defined in Figure 3-7 and Table 3-1.

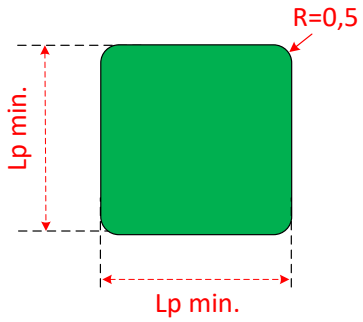

Figure 3-7 – Requirement on the minimum size contact area for the (+) and (-) contacts

Requirement 2: The electrical contact areas of the LED Array shall at least cover the overlap areas. Figure 3-8, in combination with Table 3-1 defines the position and size of the overlap area for the (+) and (-) contacts (indicated by the green areas in Figure 3-8). The center of the overlap areas coincides with the position indicated by Dx and Dy.

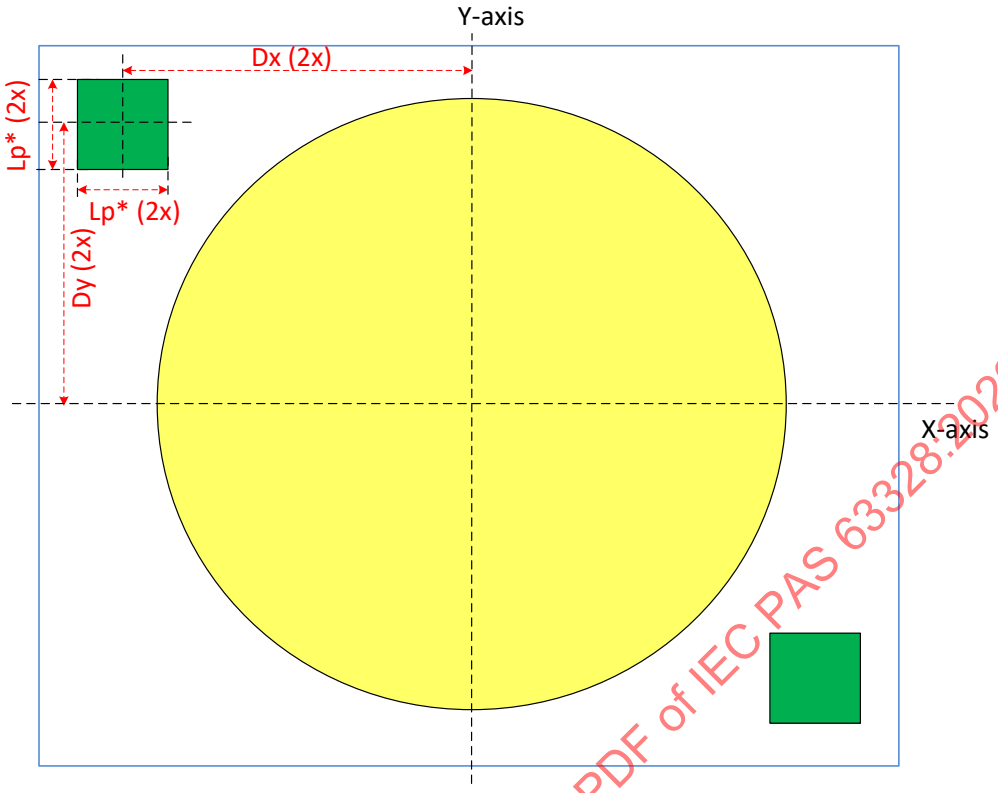

Figure 3-8 – Requirement on the overlap area for the (+) and (-) contacts – top view

(Informative)
For the Book 12 LED Array categories 28x28, 24x24 and 20x24, the minimum electrical contact area as defined above allows for a clearance of 1,9 mm between the edge of the PCB and the electrical contact area. This corresponds to a mains voltage compatible creepage and clearance distance of 1,6 mm, taking into account a PCB tolerance of 0,2 mm and a V-groove tolerance of 0,1 mm.

For the Book 12 LED Array categories 19x19, 16x19 and 12x15, the minimum electrical contact area as defined above allows for a clearance of 1,1 mm between the edge of the PCB and the electrical contact area. This corresponds to a SELV compatible creepage and clearance distance of 0,8 mm taking into account a PCB tolerance of 0,2 mm and a V-groove tolerance of 0,1 mm.

For the Book 12 LED Array category 13.5x13.5, the minimum electrical contact area as defined above allows for a clearance of 0,85 mm between the edge of the PCB and the electrical contact area. The dimensions follow existing designs, but no general tolerance for PCB and V-groove is given. Actual electrical creepage and safety can be achieved by individual measures, and might have to be supported by an insulating TIM, for example.

3.3.2.5 PCB thickness

The thickness of the PCB shall be in the range 1,0±0,15 mm.

3.3.2.6 Values of dimensions for the Book 12 LED Array categories

Table 3-1 – Values of dimensions for the Book 12 LED Array categories

LED Array category Designation	W	L	DW	Sx	Sy	ØH	Dx	Dy	Lp Min.	Lp*
C28x28	28,0	28,0	0,2	11,4	11,4	3,1	11,1	11,1	2,0	1.7
C24x24	24,0	24,0	0,2	9,4	9,4	3,1	9,1	9,1	2,0	1.7
C20x24	20,0	24,0	0,2	-	-	-	9,1	7,1	2,0	1.7
C19x19	19,0	19,0	0,2	-	-	-	7,525	7,525	1,75	1.45
C16x19	16,0	19,0	0,2	-	-	-	7,525	6,025	1,75	1.45
C13.5x13.5	13,5	13,5	0,15				5,25	5,25	1,3	1,3
C12x15	12,0	15,0	0,2	-	-	-	5,6	4,1	1,6	1,3

NOTE The values in Table 3-1 are nominal values. The number of digits behind the comma does not define the required accuracy.

3.3.3 Dimensions depending on LED Array category and LES Category

3.3.3.1 Keep-in zone (Økeep-in)

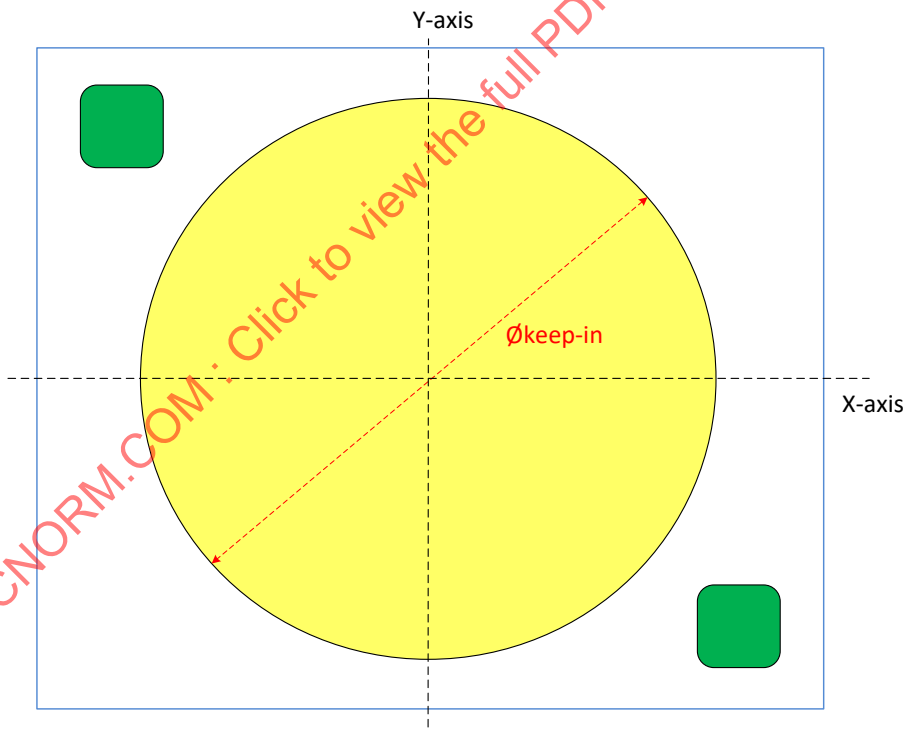

Figure 3-9 – Definition of the keep-in zone

Figure 3-9, in combination with Table 3-2 defines the position and size of the keep-in zone for components (indicated by the yellow area in Figure 3-9). The center of this keep-in area coincides with the mechanical reference point. The reference X-axis and Y-axis are axes of symmetry of the keep-In zone. Outside this keep-in zone, the LED Array shall not have any feature that protrudes above the PCB top surface. PCB tracks and contact areas are not considered as features that fall in this category.

(Informative)

A LED Array will only comply with this requirement if, for example light emitting components, LES dam and other electrical components are within the keep-in zone, as defined above.

Note that Økeep-in depends on the LED Array category as well as on the LES category. The keep-in zone depends on the LED Array category because it is limited by the outline and the contact areas. On top of that, the keep-in zone is restricted by the maximum opening in the Optics Contact Area. This maximum opening is defined as ØOCAmax in other Zhaga books which specify spot modules and depends on the LES category.

Table 3-2 – Values of dimension Økeep-in depending on the LED Array category and the LES Category

		LES category					
		LES6.3	**LES9**	**LES13.5**	**LES19**	**LES23**	**LES30**
LED Array category	**C28x28**	8,3	11,0	15,5	21,0	25,0	25,8
	C24x24	8,3	11,0	15,5	21,0	21,1	x
	C20x24	8,3	11,0	15,5	17,8	x	x
	C19x19	8,3	11,0	15,5	16,8	x	x
	C16x19	8,3	11,0	13,8	13,8	x	x
	C13.5x13.5	8,3	11,2[3]	11,2	x	x	x
	C12x15	8,3	9,8	9,8	x	x	x

3.3.3.2 Maximum electrical contact area

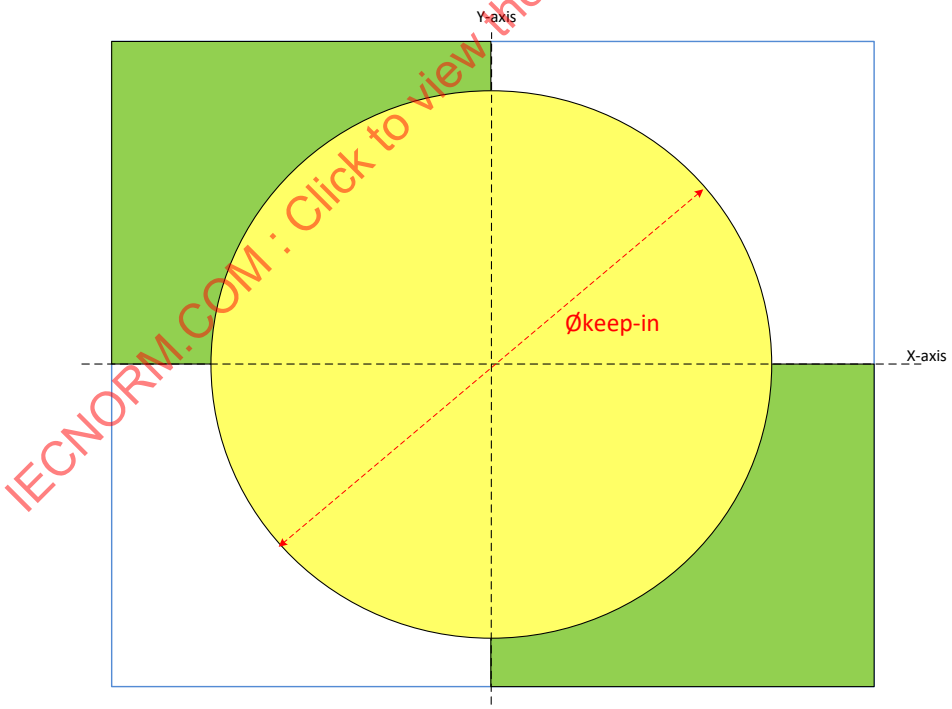

Figure 3-10 – Definition of the maximum electrical contact area – top view

[3] According to calculations used to specify C13.5x13.5, this larger value of 11,2 is possible. The other LED Array categories keep their original value of 11,0 for compatibility reasons in this Edition 1.2 of this book.

Figure 3-10, in combination with Table 3-1 and Table 3-2 defines the position and size of the maximum electrical contact area (indicated by the green areas in Figure 3-10). The electrical contacts of the LED Array under test shall be completely within these areas. PCB tracks which function as live parts are only allowed in the keep-in area (indicated by the yellow areas in Figure 3-10) and in the maximum electrical contact area (indicated by the green areas in Figure 3-10).

3.4 Mechanical interface of the Holder

On top of the requirements in this section, a Book-12 Holder shall also comply with the relevant provisions in [Book 10].

This Zhaga Book 12 defines seven form factors for Holders corresponding to the LED Array categories and identified by designations. For each of these categories, this Book 12 defines:

- The outline of the cavity of the LED Array.
- The position of the contacts.

A Book 12 Holder is intended for LED Arrays with specific LES categories as defined in [Book 1]. The largest LES category that can be accommodated in the Holder is denoted maximum LES category. For each combination of a LED Array category and a maximum LES category, this Book 12 defines:

- The keep-out zone ($Ø_{keep\text{-}out}$) being the area in the cavity of the Holder where material/components are not allowed.

(informative)

This edition of Zhaga Book 12 does not contain restrictions on the depth of the cavity of the Holder. When applying a specific LED Array in a specific Holder, it is recommended to design the system such that the LED Array and Thermal Interface Material are applied according to the design-in guide of the Holder.

3.4.1 Mechanical references for a Holder

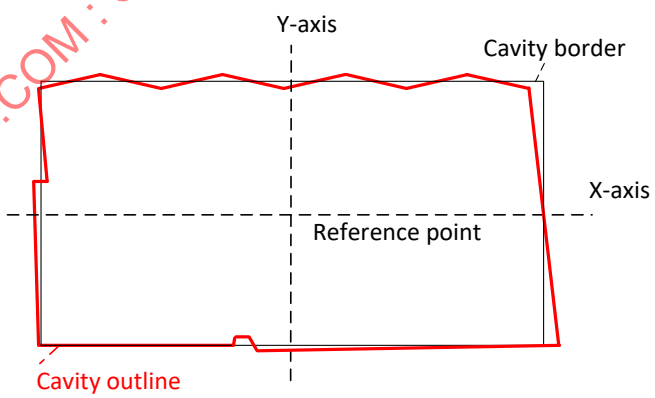

Figure 3-11 – Definition of the Cavity Border and mechanical references

By way of example, the red shape in Figure 3-11 indicates the outline of a cavity of a Book 12 Holder. By definition, the cavity border is the rectangle that fits the cavity outline such that the average deviation between cavity outline and cavity border is minimal. Also by definition, both the X-axis and the Y-axis are axes of symmetry of the cavity border. The mechanical reference point is where the X-axis and the Y-axis cross.

Typically, the outline of a Holder is not a regular rectangle. Instead it may feature mechanical reference elements and springs. In Annex B the cavity outline for these kinds of Holders is defined.

3.4.2 Dimensions depending on the LED Array category

3.4.2.1 Outline of the cavity for the LED array

The outline of the cavity in the Holder for the LED Array shall be in the demarcation zone indicated by the green area in Figure 3-12. The reference X-axis and Y-axis are axes of symmetry of dimensions L_h and W_h. For each Book 12 LED Array category the values of the dimensions of the Holder are listed in Table 3-3.

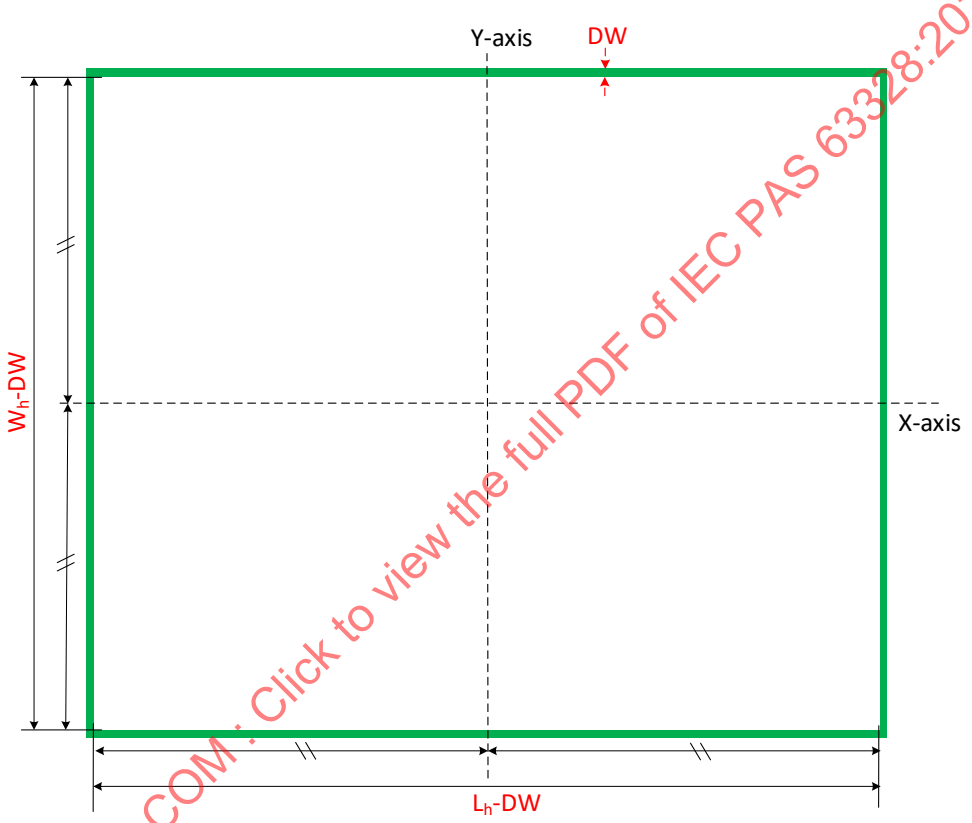

Figure 3-12 – Demarcation model for the outline of the cavity for the LED Array

3.4.2.2 Position of the contacts of the Holder

The position of center of the electrical contacts of the Holder shall be in the green areas indicated in Figure 3-13. The reference X-axis and Y-axis are axes of symmetry. For each Book 12 LED Array category the values of the dimensions of the Holder are listed in Table 3-3.

The position of center of the electrical contacts of the Holder is by definition the position of this center while the LED array is mounted in the Holder.

Note that the size of the electrical contact is not restricted in this specification.

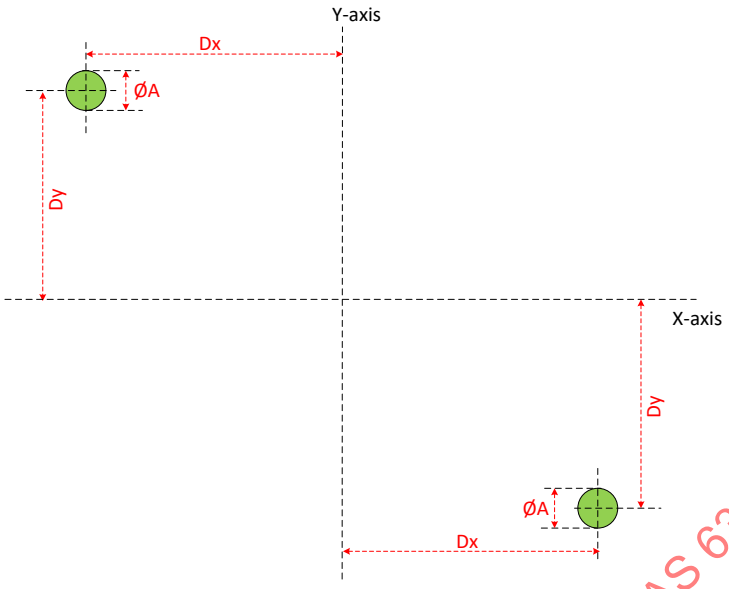

Figure 3-13 – Definition of the position of the electrical contacts of the Holder

3.4.2.3 Values of dimensions for the Book 12 LED Array categories

Table 3-3 – Values of Holder dimensions depending on the Book 12 LED Array categories

LED Array Category Designation	W_h	L_h	DW	Dx	Dy	ØA
C28x28	28,4	28,4	0,2	11,1	11,1	0,6
C24x24	24,4	24,4	0,2	9,1	9,1	0,6
C20x24	20,4	24,4	0,2	9,1	7,1	0,6
C19x19	19,4	19,4	0,2	7,525	7,525	0,4
C16x19	16,4	19,4	0,2	7,525	6,025	0,4
C13.5x13.5	13,7	13,7	0,1	5,25	5,25	0,4
C12x15	12,4	15,4	0,2	5,6	4,1	0,4

3.4.3 Dimensions depending on LED Array category and maximum LES Category

3.4.3.1 Keep-out zone (Økeep-out)

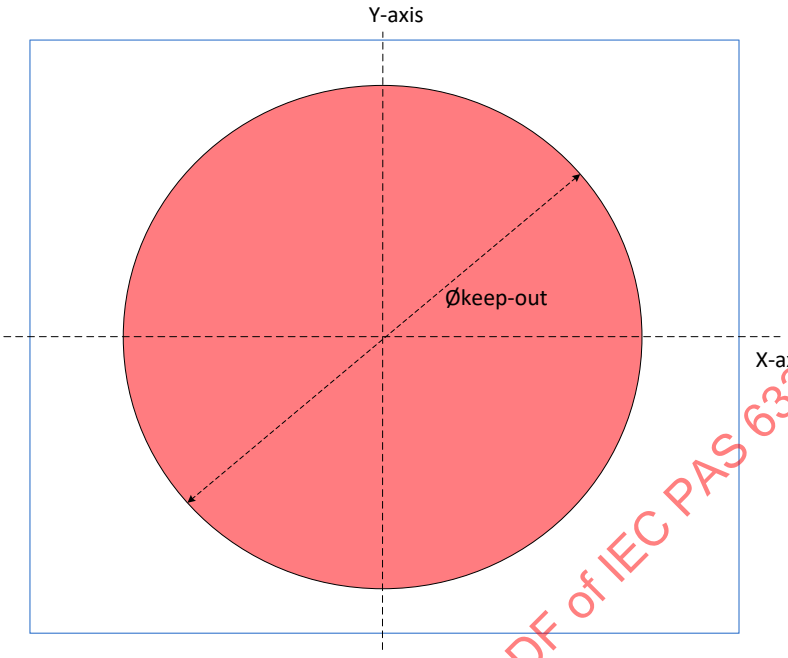

Figure 3-14 – Definition of the keep-out zone

The keep-out zone of the Holder is defined by the red area in Figure 3-14 [4]. This area in the Holder shall be void. The reference X-axis and Y-axis are axes of symmetry. For each Book 12 LED Array category and each maximum LES category, the value of Økeep-out is listed in Table 3-4.

Table 3-4 – Values of dimension Økeep-out depending on the LED Array category and the maximum LES Category

		Maximum LES category					
		LES6.3	LES9	LES13.5	LES19	LES23	LES30
LED Array category	C28x28	8,3	11,0	15,5	21,0	25,0	25,8
	C24x24	8,3	11,0	15,5	21,0	21,1	x
	C20x24	8,3	11,0	15,5	17,8	x	x
	C19x19	8,3	11,0	15,5	16,8	x	x
	C16x19	8,3	11,0	13,8	13,8	x	x
	C13.5x13.5	8,3	11,2 [5]	11,2	x	x	x
	C12x15	8,3	9,8	9,8	x	x	x

4 The keep-out zone of the Holder is equal to the keep-in zone of the corresponding LED Array.

5 According to calculations used to specify C13.5x13.5, this larger value of 11,2 is possible. The other categories' keep-outs can also use the value 11,2 in this Edition 1.2 of this book.

4 Photometric interface

4.1 Light Emitting Surface

For the purpose of this section, the provisions in [Book 1] – section 4.1, apply. The LES for Book 12 LED Arrays shall be described by a 2-dimensional circle parallel to the reference plane defined in Figure 3-1. It has a physical boundary or is a virtual surface in the surrounding area of the LED Array.

The circle shall have the smallest possible diameter while complying with the following conditions:

- When seen from above, all light emitting parts (LED, diffuse cover and / or mixing chamber) are covered by the LES.
- It encircles all pixels in the luminance image of the LED Array that have a value >10 % of the maximum (See Annex C).

The height of the LES is by definition the lowest value while complying with the condition that all light emitting parts are behind the LES, when seen in a top view. The typical height of the LES is 2 mm. This height should be taken as a reference by the luminaire manufacturer in designing Luminaire Optics.

The center of the LES should not be off from the Z-axis of the LED Array by more than 1 mm in X- and Y- direction.

Book 12 LED Arrays shall have a LES in one of the categories LES6.3, LES9, LES13.5, LES19, LES23 or LES30 as defined in [Book 1] – section 4.1.1.

4.2 Operating conditions

For the LED Array defined in this Book 12, the operating conditions defined in [Book 1] – section 4.2 apply.

4.3 Luminous flux

For the purpose of this section, the provisions in [Book 1] – section 4.3 apply. The luminous flux of a LED Array shall be measured under the conditions specified in section 4.2.

4.4 Luminous intensity distribution

For the purpose of this section, the provisions in [Book 1] – section 4.4 apply. The luminous intensity distribution of a LED Array shall be measured under the conditions specified in section 4.2 with the exception that the Reference Temperature may be stabilized at any temperature as only relative values are considered for the luminous intensity distribution.

It is recommended that the LED Array has a luminous intensity distribution that is as close as possible to a lambertian intensity distribution. There is no requirement regarding FWHM of the luminous intensity distribution. Relative Partial Luminous Fluxes for the polar angle regions as defined in [Book 1] – section 4.4 shall be within the limits defined in Table 4-1.

Table 4-1 – Relative partial luminous flux requirements

γ_1	γ_2	Relative Partial Luminous	
		Minimum	Maximum
0°	41,40°	39%	56%
41,40°	60,00°	31%	37%
60,00°	75,50°	11%	22%
75,50°	90°	0%	7%

4.5 Luminance uniformity

For the purpose of this section, the provisions in [Book 1] – section 4.5 apply. The luminance uniformity of a LED Array should be measured under the conditions specified in section 4.2 with the exception that the Reference Temperature may be stabilized at any temperature as only relative values are to be considered for the luminance uniformity.

The luminance of the LED Array should be symmetric with respect to the reference Z-axis. Using the definition of the five segments A_i (i=1…5) of the LES as shown in Figure 4-1, the following symmetry parameters are defined as follows:

1) Luminance rotational symmetry

   The luminance rotational symmetry parameter S is calculated from the average luminance L_i in the forward direction in each of the four segments A_i (i=1…4) as $\frac{\min(L_i)}{\max(L_i)}$. Note that the definition of the segments shown in Figure 4-1 is not related to the orientation of the LED Array. For that reason, $\frac{\min(L_i)}{\max(L_i)}$ shall be calculated for different orientation (see Annex C). The luminance rotational symmetry (S) is defined as $S = \max\left(\frac{\min(L_i)}{\max(L_i)}\right)$. The value of S should not be lower than 0,5.

2) Luminance center balance

   The Luminance center balance is defined as: $B = \frac{L_5}{\text{Average}\,(L_1 \ldots L_4)}$. The value of B should not be higher than 4.

3) Luminance uniformity

   The luminance uniformity U is defined as $U = \frac{L_{avg}}{L_{RMS}}$ with

   L_{avg} : the average luminance over the actual LES area [6].

   $L_{RMS} = \sqrt{\frac{1}{N}\Sigma L_j^2}$: the RMS luminance values over every pixel in the actual LES area.

[6] For this requirement, not the LES category diameter but the actual LES diameter determined in 8.2.5 shall be used.

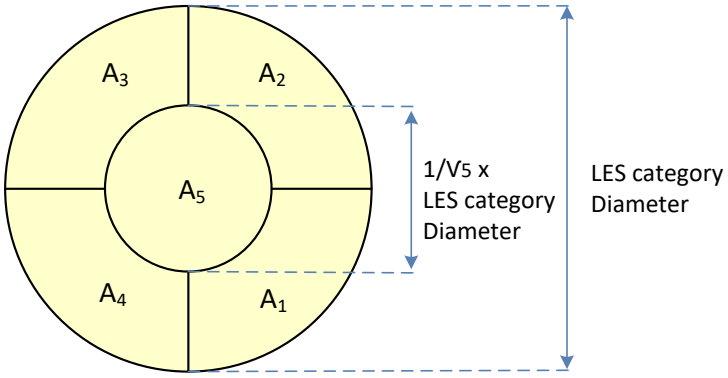

Figure 4-1 – Luminance property evaluation areas

4.6 Correlated color temperature

For the purpose of this section, the provisions in [Book 1] – section 4.6 apply. The correlated color temperature of a LED Array shall be measured under the conditions specified in section 4.2.

4.7 Color rendering index

For the purpose of this section, the provisions in [Book 1] – section 4.7 apply. The color rendering index of a LED Array shall be measured under the conditions specified in section 4.2.

5 Electrical interface of the LED Array

5.1 Electrical interface of the LED Array

The LED Array defined in this Book 12 shall comply with the provisions of [LEDset-Pow].

The LED Array defined in this Book 12 shall comply with the provisions of [LEDset-Inf].

5.2 Electrical insulation of the LED Array (informative)

For the purpose of this section, the provisions in [Book 1] – section 5.1, apply.

6 Thermal interface

6.1 Background information (informative)

For the purpose of this section, the provisions in [Book 1] – section 6.1 apply.

6.2 Generic thermal interface model

6.2.1 General case

For the purpose of this section, the provisions in [Book 1] – section 6.2.1 apply.

6.2.2 Rated Operating Temperature and safety (informative)

For the purpose of this section, the provisions in [Book 1] – section 6.2.3 apply.

6.2.3 Thermal overload protection (informative)

For the purpose of this section, the provisions in [Book 1] – section 6.2.4 apply.

6.2.4 Thermal compatibility check

In order to determine whether a particular LED Array is thermally compatible with a particular Luminaire, it should be verified that the LED Array-Luminaire combination will operate at $t_r \leq t_{r,max}$. The value of $t_{r,max}$ is listed in the LED Array Product Data Set. Using the generic thermal model as defined in [Book 1] – section 6.2.1, the operating temperature t_r can be determined by:

$$t_r = t_a + R_{th} \cdot P_{th,rear} \quad \text{EQ. 6-1}$$

The ambient temperature t_a is determined by the application of the LED Array-Luminaire combination. The value of R_{th} is a characteristic of the heat sink. Both t_a and R_{th} should be chosen appropriately by a skilled person.

The value of $P_{th,rear}$ is not listed in the LED Array Product Data Set. However, it can be estimated using the Rated value of P_{th} in the LED Array Product Data Set.

(Informative)
Depending on the required accuracy of the estimation of $P_{th,rear}$, the following methods may be used.

Method 1 – Ignore $P_{th,front}$

In this case $P_{th,rear} = P_{th}$

Method 2 – Estimate $P_{th,front}$ using a thermal simulation.

In this case, $P_{th,rear}$ is calculated using: $P_{th,rear} = P_{th} - P_{th,front}$ and $P_{th,front}$ is estimated using a thermal simulation of the LED Array in the specific application. This allows the characteristics of the Luminaire also to be taken into account.

6.2.5 Thermal Interface Material

For the purpose of this section, the provisions in [Book 1] – section 6.2.9 apply.

6.2.6 Surface planarity and roughness

For the purpose of this section, the provisions in [Book 1] – section 6.2.10 apply. It is recommended that the surface in the Luminaire which serves as a thermal interface has a surface planarity smaller than 0,1 mm and a surface roughness smaller than 3,2 µm.

6.2.7 Aging of LED Array (informative)

For the purpose of this section, the provisions in [Book 1] – section 6.2.11 apply.

Part 2: Compliance Tests

7 Compliance test tools

7.1 LED Array test tools

7.1.1 Test Fixture PETF

The PETF for Book 12 LED Arrays is a temperature controlled heat sink that allows for mounting the LED Array under test and that can be attached to the photometric measurement system.

The means for mounting the LED Array to the PETF (for example a Holder) as well as the Thermal Interface Material to be used shall be supplied by the LED Array manufacturer when submitting the LED Array for compliance test to the ATC.

7.2 Holder test tools

7.2.1 Gauges for Holder cavity test

The gauges for the Holder cavity compliance test are defined in Figure 7-1. For each Book 12 LED Array category, the values of the dimensions are listed in Table 7-1. The thickness of the gauge shall be about 1 mm.

The actual dimensions of the gauge shall comply with the definition in this section within a tolerance of +/- 0,01 mm.

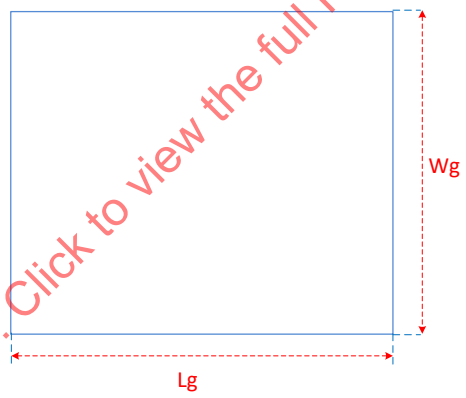

Figure 7-1 – Definition of the gauges for the holder cavity compliance test

Table 7-1 – Values of dimensions of the gauges for the Holder cavity compliance test

LED Array category Designation	Wg	Lg
C28x28	28,2	28,2
C24x24	24,2	24,2
C20x24	20,2	24,2
C19x19	19,2	19,2
C16x19	16,2	19,2
C13.5x13.5	13,65	13,65
C12x15	12,2	15,2

7.2.2 Gauges for Holder contact test

7.2.2.1 Gauges for Holder contacts with minimum thickness

The gauges for the Holder contacts compliance test are defined in Figure 7-2. The reference X-axis and Y-axis are axes of symmetry for the outline. The green areas indicate contact areas. The two contact areas shall be electrically connected but the electrical connection shall not influence the effective size of the contact areas[7]. For each Book 12 LED Array category, the values of the dimensions are listed in Table 7-2. The thickness of the gauge equals 0,85 mm.

The actual dimensions of the gauge shall comply with the definition in this section within a tolerance of +/- 0,01 mm. For gauges used to check concept-1 Holders (see section 9.1.2), the required tolerance on the thickness equals +/- 0,05 mm.

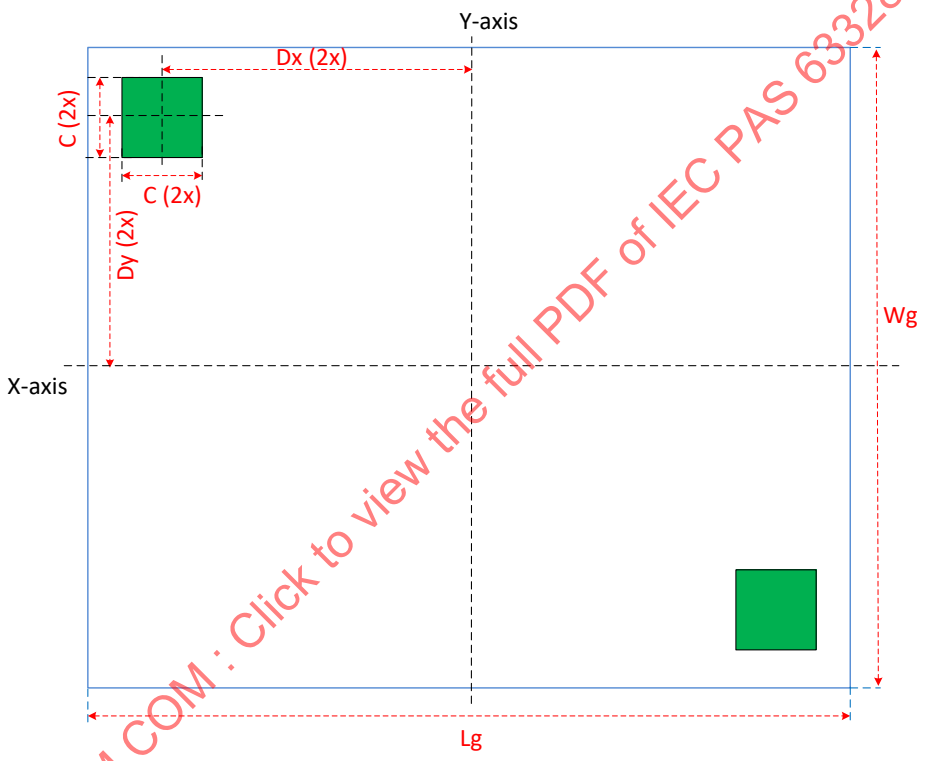

Figure 7-2 – Definition of the gauges for the holder contacts compliance test

7 This can be realized by, for example a connection via the back of the gauge or via a connecting track covered by an insulating layer.

Table 7-2 – Values of dimensions of the gauges for the Holder contacts compliance test

LED Array category Designation	Wg	Lg	Dx	Dy	C
C28x28	27,8	27,8	11,1	11,1	1,5
C24x24	23,8	23,8	9,1	9,1	1,5
C20x24	19,8	23,8	9,1	7,1	1,5
C19x19	18,8	18,8	7,525	7,525	1,25
C16x19	15,8	18,8	7,525	6,025	1,25
C13.5x13.5	13,4	13,4	5,25	5,25	1,1
C12x15	11,8	14,8	5,6	4,1	1,1

7.2.2.2 Gauges for Holder contacts with maximum thickness

Apart from the thickness of the gauge, gauges for Holder contacts with maximum thickness have the same definition as gauges for Holder contacts with minimum thickness (section 7.2.2.1). The thickness of gauges for Holder contacts with maximum thickness equals 1,15 mm. For gauges used to check concept-1 Holders (see section 9.1.2), the required tolerance on the thickness equals +/- 0,05 mm.

8 LED Array Compliance Tests

8.1 LED Array mechanical interface tests

8.1.1 Test of the demarcation of the LED Array without mounting holes and without mouse bites

This test is only applicable for Book 12 LED Arrays that neither have mounting holes nor mouse bites. The purpose of this test is to verify the demarcation of the LED Array under test.

8.1.1.1 Test equipment

This test should be conducted with measuring equipment like a non-contact optical measuring system. The measurement accuracy shall be at least +/- 0,01 mm.

8.1.1.2 Test conditions

This test shall be conducted at 25 ± 5 ℃.

8.1.1.3 Test procedure

- Determine the designation of the LED Array category from the Product Data Set of the LED Array under test.
- Find the corresponding LED Array Demarcation in section 3.3.2.1.
- Determine the reference X-axis and Y-axis of the LED Array according to the definition section in section 3.3.1.
- Align the reference axes of the LED Array with the reference axes of the demarcation model in Figure 3-3.
- Verify that the LED Array under test complies with the requirements in section 3.3.2.1. Additional guidelines for this test are provided in [Book-1], annex B.

8.1.1.4 Pass criteria

The LED Array under test passes if it complies with the requirements in section 3.3.2.1 with a tolerance of 0,01 mm.

8.1.2 Test of the demarcation of the LED Array C28x28 or C24x24 with mounting holes

This test is only applicable for Book 12 LED Arrays C28x28 and C24x24 that feature mounting holes. The purpose of this test is to verify the demarcation of the LED Array under test.

8.1.2.1 Test equipment

This test should be conducted with measuring equipment like a non-contact optical measuring system. The measurement accuracy shall be at least +/- 0,01 mm.

8.1.2.2 Test conditions

This test shall be conducted at 25 ± 5 °C.

8.1.2.3 Test procedure

- Determine the designation of the LED Array category from the Product Data Set of the LED Array under test.
- Find the corresponding LED Array Demarcation in section 3.3.2.2.
- Determine the reference X-axis and Y-axis of the LED Array according to the definition section in section 3.3.1.
- Align the reference axes of the LED Array with the reference axes in Figure 3-4.
- Verify that the LED Array under test complies with the requirements in section 3.3.2.2. Note that such verification includes the outline of the LED Array under test as well as the size, shape and position of the mounting holes within that outline. Additional guidelines for this test are provided in [Book-1], annex B.

8.1.2.4 Pass criteria

The LED Array under test passes if it complies with the requirements in section 3.3.2.2 with a tolerance of 0,01 mm.

8.1.3 Test of the demarcation of the LED Array C20x24, C19x19, C13.5x13.5 or C12x15 with mouse bites

This test is only applicable for Book 12 LED Arrays C20x24, C19x19, C13.5x13.5 or C12x15 that feature mouse bites. The purpose of this test is to verify the demarcation of the LED Array under test.

8.1.3.1 Test equipment

This test should be conducted with measuring equipment like a non-contact optical measuring system. The measurement accuracy shall be at least +/- 0,01 mm.

8.1.3.2 Test conditions

This test shall be conducted at 25 ± 5 °C.

8.1.3.3 Test procedure

- Determine the designation of the LED Array category from the Product Data Set of the LED Array under test.
- Find the corresponding LED Array Demarcation in section 3.3.2.3.
- Determine the reference X-axis and Y-axis of the LED Array according to the definition section in section 3.3.1.
- Align the reference axes of the LED Array with the reference axes in Figure 3-5.

- Verify that the LED Array under test complies with the requirements in section 3.3.2.3. Additional guidelines for this test are provided in [Book-1], annex B.

8.1.3.4 Pass criteria

The LED Array under test passes if it complies with the requirements in section 3.3.2.3 with a tolerance of 0,01 mm.

8.1.4 Test of the electrical contact areas (+) and (-) of the LED Array

The purpose of this test is to verify the size and position of the electrical contact areas (+) and (-) of the LED Array under test.

8.1.4.1 Test equipment

This test should be conducted with measuring equipment like a non-contact optical measuring system. The measurement accuracy shall be at least +/- 0,01 mm.

8.1.4.2 Test conditions

This test shall be conducted at 25 ± 5 ℃.

8.1.4.3 Test procedure

- Determine the designation of the LED Array category from the Product Data Set of the LED Array under test.
- Find the corresponding minimum electrical contact area in section 3.3.2.4.
- Determine the reference X-axis and Y-axis of the LED Array according to the definition section in section 3.3.1.
- Align the reference axes of the LED Array with the reference axes in Figure 3-8.
- Verify that the electrical contacts areas of the LED Array under test comply with the requirements in section 3.3.2.4. Additional guidelines for this test are provided in [Book-1], annex B.
- Determine the designation of the LES category from the Product Data Set of the LED Array under test.
- Find the corresponding maximum electrical contact area in section 3.3.3.2.
- Verify that the electrical contacts areas of the LED Array under test comply with the requirements in section 3.3.3.2. Additional guidelines for this test are provided in [Book-1], annex B.

8.1.4.4 Pass criteria

The LED Array under test passes if the electrical contact areas (+) and (-) of the LED Array comply with the requirements in sections 3.3.2.4 and 3.3.3.2 with a tolerance of 0,01 mm.

8.1.5 Test of the keep-in zone of the LED Array

The purpose of this test is to verify the size and position of the keep-in zone of the LED Array under test.

8.1.5.1 Test equipment

This test should be conducted with measuring equipment like a non-contact optical measuring system. The measurement accuracy shall be at least +/- 0,01 mm.

8.1.5.2 Test conditions

This test shall be conducted at 25 ± 5 ℃.

8.1.5.3 Test procedure

- Determine the designation of the LED Array category from the Product Data Set of the LED Array under test.
- Determine the designation of the LES category from the Product Data Set of the LED Array under test.
- Find the corresponding keep-in zone in section 3.3.3.1.
- Determine the reference X-axis and Y-axis of the LED Array according to the definition section in section 3.3.1.
- Align the reference axes of the LED Array with the reference axes in Figure 3-9.
- Verify that the LED Array under test complies with the requirements in section 3.3.3.1. Additional guidelines for this test are provided in [Book-1], annex B. In order to make sure that the complete dam is taken into account in this test, the focus point of the measuring equipment should be at the top surface of the PCB.

8.1.5.4 Pass criteria

The LED Array under test passes if it complies with the requirements in section 3.3.3.1 with a tolerance of 0,01 mm.

8.1.6 Test of the thickness of the PCB of the LED Array

The purpose of this test is to verify the thickness of the PCB of the LED Array under test.

8.1.6.1 Test equipment

This test should be conducted with a caliper. The measurement accuracy shall be at least +/- 0,02 mm.

8.1.6.2 Test conditions

This test shall be conducted at 25 ± 5 °C.

8.1.6.3 Test procedure

- Measure the thickness of the PCB of the LED Array under test in the area outside the keep-in zone as defined in section 3.3.3.1.

8.1.6.4 Pass criteria

The LED Array under test passes if measured thickness complies with the requirements in section 3.3.2.5 with a tolerance of 0,01 mm.

8.2 LED Array photometric interface tests

8.2.1 Test on luminous flux

For the purpose of this section, the provisions in [Book 1] – section A.0.2.1 apply. The Test Fixture PETF is defined in section 7.1.1. The test conditions are defined in section 4.2.

8.2.2 Test on relative partial luminous flux and beam angle

For the purpose of this section, the provisions in [Book 1] – section A.0.2.2 apply. The Test Fixture PETF is defined in section 7.1.1. The test conditions are defined in section 4.2.

8.2.3 Test on correlated color temperature (CCT)

For the purpose of this section, the provisions in [Book 1] – section A.0.2.3 apply. The Test Fixture PETF is defined in section 7.1.1. The test conditions are defined in section 4.2.

8.2.4 A.1.2.4 Test on color rendering index

For the purpose of this section, the provisions in [Book 1] – section A.0.2.4 apply. The Test Fixture PETF is defined in section 7.1.1. The test conditions are defined in section 4.2.

8.2.5 Test on luminance uniformity & LES diameter

This edition of Book 12 of the Zhaga Interface Specification does not contain compliance tests for the luminance uniformity and LES.

8.3 LED Array thermal interface tests

8.3.1 Test on thermal power (P_{th})

For the purpose of this section, the provisions in [Book 1] – section A.0.3.1 apply. The Test Fixture PETF is defined in section 7.1.1. The test conditions are defined in section 4.2.

8.3.2 Temperature stabilization

For the purpose of this section, the provisions in [Book 1] – section A.1.3.5 apply.

8.3.3 Position of measurement point for the Reference Temperature

For the purpose of this section, the provisions in [Book 1] – section A.1.3.6 apply.

8.4 LED Array electrical interface tests

All LED Module compliance tests as defined in [LEDset-Pow] shall be conducted and the LED-Module-under-test passes if all these tests pass.

All LED Array compliance tests as defined in [LEDset-Inf] shall be conducted and the LED Array under test passes if all these tests pass.

8.5 LED Array Product Data Set test

For the purpose of this section, the provisions in [Book 1] – section A.0.5 apply.

9 Holder Compliance Tests

9.1 Holder mechanical interface tests

On top of the compliance tests listed in this section, the Holder under test shall also comply with the Holder related compliance test listed in [Book-10].

9.1.1 Test of the outline of the cavity of the Holder

The purpose of this test is to verify whether the outline of the cavity of the Holder under test is equal or larger than the minimum outline[8].

9.1.1.1 Test equipment

This test shall be conducted with a gauge as defined in section 7.2.1.

9.1.1.2 Test conditions

This test shall be conducted at 25 ± 5 ℃.

[8] The verification whether the cavity is equal or smaller than the maximum cavity is (indirectly) performed with the test of electrical contacts (section 9.1.2).

9.1.1.3 Test procedure

- Determine the designation of the LED Array category from the Product Data Set of the Holder under test.
- Find the corresponding gauge section 7.2.1.
- Mount the gauge in the Holder under test according to the mounting instructions provided with the Holder and verify whether the gauge fits in the cavity of the Holder. In case that Holder mounting screw holes are completely or partly within the cavity, this verification shall be done with mounting screws in the mounting holes.

9.1.1.4 Pass criteria

The Holder under test passes if the gauge fits in the cavity of the Holder.

9.1.2 Test of the electrical contacts (+) and (-) of the Holder[9]

The purpose of this test is to verify the position of the electrical contacts (+) and (-) of the Holder under test.

9.1.2.1 Test equipment

This test shall be conducted with a test gauge as defined in section 7.2.2.

9.1.2.2 Test conditions

This test shall be conducted at 25 ± 5 ℃.

9.1.2.3 Test procedure

- Determine the designation of the LED Array category from the Product Data Set of the Holder under test.
- Determine whether the Holder under test is a ‘Concept 1’ Holder (Top of the LED Array is aligned with the ‘stops’ in the Holder, Figure 9-1) or a ‘Concept 2’ Holder (bottom of the LED array is aligned with the bottom of the Holder, Figure 9-2).

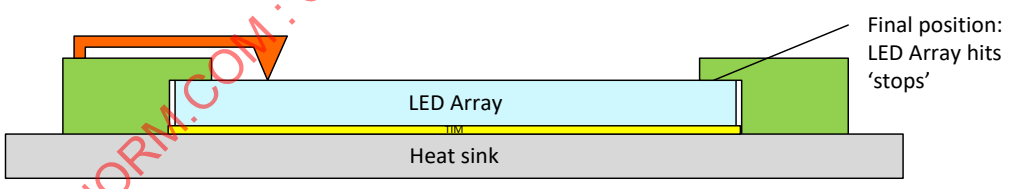

Figure 9-1 – LED array in ‘Concept 1’ Holder

9 The compliance of the electrical contacts may also be checked by means of measuring equipment like a non-contact optical measuring system and verifying whether the position of the center of the contact complies with the requirements in section 3.4.2.2.

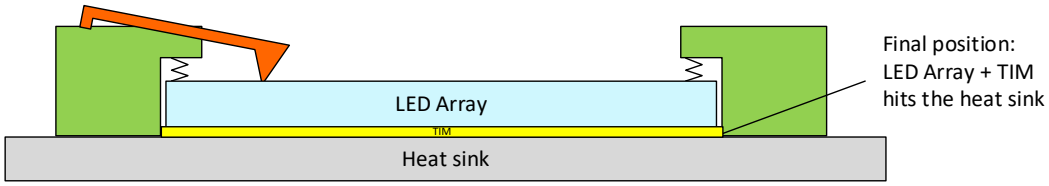

Figure 9-2 – LED array in 'Concept 2' Holder

- If the Holder under test is a 'Concept 1' Holder,
  - Find the corresponding gauge with minimum or maximum thickness as defined in section 7.2.2
  - Insert the gauge into the Holder such that the top of the gauges is aligned with the 'stops' in the Holder.
  - Connect the external contacts of the Holder to a measurement device to measure electrical contact.
  - Move the gauge in the holder to all extreme positions and check electrical contact.
- If the Holder under test is a 'Concept 2' Holder,
  - Find the corresponding gauge with minimum thickness as defined in section 7.2.2
  - Put the gauge on a heat sink with a plate in between. The thickness of the plate shall be equal to the thickness of the TIM – in compressed state prescribed in the design-in guide of the Holder manufacturer.
  - Connect the external contacts of the Holder to a measurement device to measure electrical contact.
  - Move the gauge in the holder to all extreme positions and check electrical contact.
  - Repeat the last 4 steps with a gauge with maximum thickness.

9.1.2.4 Pass criteria

The Holder under test passes if the system makes electrical contact in all positions of the gauge in the Holder.

9.1.3 Test of the keep-out zone of the Holder

The purpose of this test is to verify the size and position of the keep-out zone of the Holder under test.

9.1.3.1 Test equipment

This test should be conducted with a caliper. The measurement accuracy shall be at least +/- 0,01 mm.

9.1.3.2 Test conditions

This test shall be conducted at 25 ± 5 ℃.

9.1.3.3 Test procedure

- Determine the designation of the LED Array category from the Product Data Set of the Holder under test.
- Determine the designation of the maximum LES category from the Product Data Set of the Holder under test.
- Find the corresponding keep-out zone in section 3.4.3.1.

- Measure the diameter of the keep-out zone and verify that the Holder under test complies with the requirements in section 3.4.3.1. In case the keep-out zone is not perfectly round, the minimum diameter shall be used for this verification.

9.1.3.4 Pass criteria

The Holder under test passes if it complies with the requirements in section 3.4.3.1 with a tolerance of 0,01 mm.

9.2 Holder Product Data Set test

For the purpose of this section, the provisions in [Book 1] – section A.0.5 apply.

Annexes

Annex A

Product Data Set requirements

In this section the requirements with respect to the Product Data Sets of Zhaga products defined in this Book 12 are listed.

A.1 LED Array Product Data Set

The LED Array Product Data Sets shall contain the following information:

- LED Array category as defined in Table 3-1.
- The LES diameter.
- LES category as defined in [Book 1], section 4.1.
- Luminous flux category as defined in [Book 1] section 4.3 at the Rated Operating Temperature $t_{r,\,max}$.
- CCT and CRI category at the Rated Operating Temperature $t_{r,\,max}$ using the three digit code as defined in [IEC TR 62732]. Only the nominal CCT categories as specified in [ANSI C78.377] shall be used.
- Luminance rotational symmetry (S) according to the definition in section 4.5.
- The luminance center balance (B) according to the definition in section 4.5.
- Luminance uniformity (U) according to the definition in section 4.5.
- Rated Operating Temperature $t_{r,max}$.
- Thermal power P_{th}.

On top of the parameters listed above, the LED Array PDS shall also include those parameters related to the electrical interface that are mandated PDS items in [LEDset-Pow].

A.2 Holder Product Data Set

The Holder Product Data Sets shall contain the following information:

- LED Array category as defined in Table 3-1.
- Maximum LES category as defined in [Book 1], section 4.1.
- Thermal Interface Material (type or properties) to be applied with this Holder, possibly depending on thickness and material of the LED Array.

On top of the parameters listed above, the Holder PDS shall also include those parameters that are mandated PDS items for Holders in [Book-10].

Annex B

Definition of the cavity outline and mechanical reference of the Holder

In section 3.4.1 the cavity border and mechanical reference is defined for cavity outlines which are basically rectangular. In this annex, this definition is expanded for more typical designs with mechanical reference elements and springs.

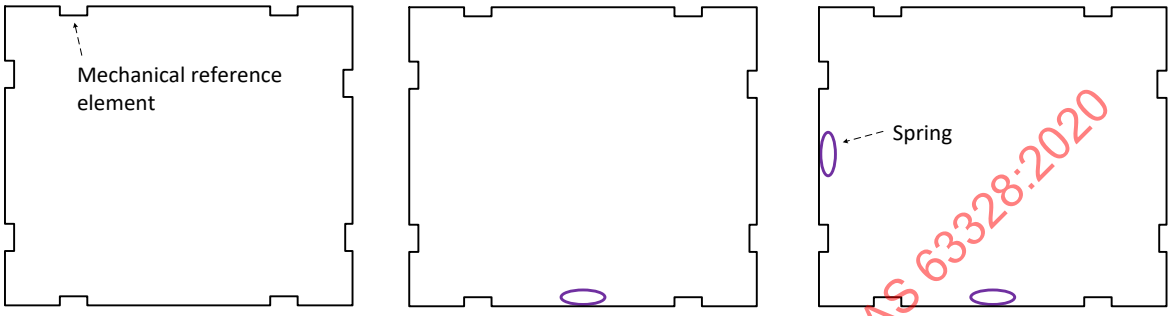

Figure B-1 – Examples of cavity outlines in a Holder

A few examples of typical outlines of cavities in Holders are depicted in Figure B-1. Generally, the LED array is fixed in the cavity by means of mechanical reference elements and possibly springs.

For the definition of the cavity border and the mechanical reference for these kinds of Holders, the mechanical reference elements are leading and the springs are ignored. The effective cavity outline to be used to determine the mechanical reference is depicted by the blue dashed line in Figure B-2. Note that this definition of the effective cavity outline is by way of example. The actual outline of the cavity is not restricted by this definition.

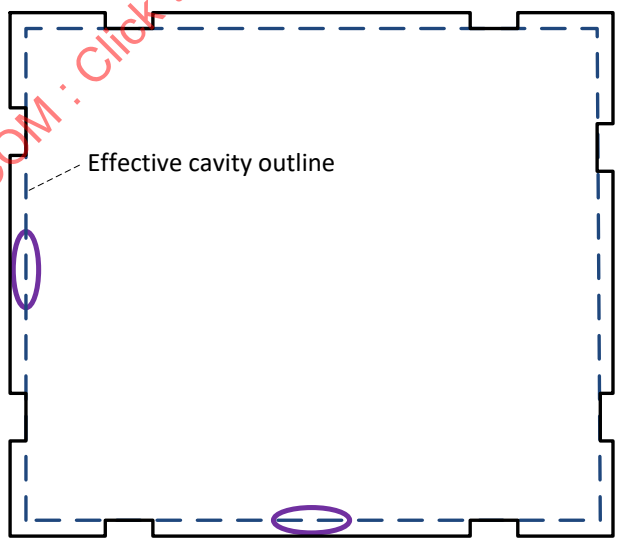

Figure B-2 – Definition of the effective cavity outline of a Holder

Annex C

Guidelines for LES and Luminance measurements (informative)

The Light Emitting Surface and the LES diameter for a Book 12 LED Module are defined in section 4.1 while the luminance uniformity parameters B, S and U are defined in section 4.5. This annex provides guidance on how to measure these parameters. Note that this section is informative only. Other methods to determine the value of these parameters may also be used. As an example one may calculate these values from ray-set data of the device under test.

C.1 Test equipment

The luminance uniformity and the LES diameter can be measured using a setup as depicted in Figure C-1. The luminance camera should have sufficient resolution to measure at least 500 pixels over the actual LES area. The measurement uncertainty for the luminance value should be +/- 10 % or less[10].

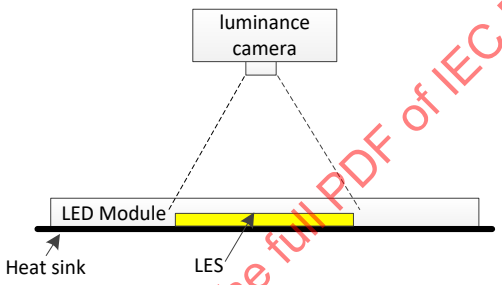

Figure C-1 – Set-up for measurement of luminance uniformity and LES diameter

C.2 Test conditions

See section 4.2.

C.3 Test procedure

- 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-under-test on a suitable heat sink. The luminance camera should measure the luminance directly looking at the LED-Module-under-test along the Z-axis (Figure 3-1). Ensure that the whole LED-Module-under-test is in the field of vision of the luminance camera.
- Choose the focus of the luminance camera to be in the plane of the OCA, not on the LEDs.
- Turn on the LED-Module-under-test.
- As only relative data is to be taken, it is not necessary to wait for thermal stabilization if the duration of the measurement is less than 1 s. Otherwise, wait for stabilization of the temperature t_r (see [book 1], section A.0.3.2).

10 Evaluation of measurements is always relative in this specification. Thus, the tolerance for the luminance rotational symmetry, center balance and uniformity parameter is expected to be much lower.

- Measure the luminance image of the LED-Module-under-test. Trim the image in such a way that the LED Module is in the center of the image, and that it fills at least 80% of height and width of the image.
- Determine the center of gravity of the luminance image. The “center of gravity” of a luminance image is by definition the point which has the least summed distance to all pixels in the image. Use only pixels above the background noise level for this determination. A typical threshold level is 10% of the maximum intensity. Shift the center of the evaluation areas (Figure 4-1) such that it coincides with the “center of gravity”.
- Evaluate the average luminances L_i in the areas A_i as defined in Figure 4-1. Note that the LES category diameter shall be taken for this evaluation.
- Determine the actual LES diameter as the minimum diameter of the circle around the center of gravity of the luminance image that encloses all pixels with >10% of the maximum L_i (i=1..5).
- Rotate the orientation of the segments diagram defined in Figure 4-1 with respect to the luminance image by 90° in steps of 5°. For every step, evaluate the rotational symmetry parameter (S) as defined in section 4.5. The maximum shall be taken as value for S.
- Evaluate center balance (B) as defined in section 4.5.
- Evaluate the average luminance L_{avg} over the actual LES area.
- Calculate the luminance uniformity (U) as defined in section 4.5. The number of pixels N shall not be less than 500.

Annex D

History of Changes

Table D-1 – Changes from Edition 1.1 to Edition 1.2

Location	Change
Throughout document	Add category C13.5x13.5
1.3.1	Delete special meaning of the words ‘can’ and ‘may’
Annex B	Delete this annex and refer to book-1 for guidelines for mechanical interface test

Subdivision 2

Zhaga Interface Specification Book 1

Summary (informative)

Background

The Zhaga Consortium is a global lighting-industry organization that aims to standardize components of LED luminaires, including LED light engines, LED modules, LED arrays, holders, electronic control gear (LED drivers) and connectivity fit systems.

Zhaga has created a set of interface specifications, known as Books. Each Book defines one or more components of an LED luminaire by means of the mechanical, photometric, electrical, thermal, and control interfaces of the component to its environment. This makes such products interchangeable in the sense that it is easy to replace one product with another, even if they have been made by different manufacturers.

Contents

This Book 1 is a special book, because it does not define components of LED luminaires. Instead, this book gives an overview of the Zhaga terminology as well as common information to explain the general aspects of the interfaces defined by Zhaga. This book also defines a set of generic compliance tests, which are used to verify if a product meets the requirements defined in the relevant Zhaga interface specification.

Intended Use

This book should be read to become familiar with the basic principles of the Zhaga interface specifications. In particular, the other Zhaga interface specifications rely on the information provided in this book. This information is not duplicated in those other books.

1 General

1.1 Introduction

The Zhaga Consortium is a global organization that aims to standardize components of LED luminaires. A LED luminaire is a lighting fixture for general lighting that contains a light source based on solid-state technology. Such light sources, including LED Modules and LED Light Engines, typically consist of one or more LEDs combined with an Electronic Control Gear (LED driver). Other components of LED luminaires include LED Arrays, Holders, and connectivity fit systems.

Zhaga has created a set of interface specifications, known as Books, which define the interfaces between a component and its environment. Book 1 is a special Book in the sense that it provides common information, which is relevant to all other Books in the series. In addition, Book 1 defines requirements and compliance tests, which are applicable across multiple Zhaga books. Such Books refer to those requirements and compliance tests as applicable.

1.2 Scope

This Book 1 defines the common concepts that underlie the Zhaga interface specifications. In addition, this Book 1 specifies general requirements for Zhaga compliant components of LED Luminaires.

Each of the other Zhaga interface specifications details the requirements and the tests for particular types of Zhaga products. These Books are published separately for ease of revision and additional Books will be added as and when a need for them is recognized.

This Book 1 is to provide a set of requirements and compliance tests which are applicable to most Zhaga products and which can be called up as required by the other Books. Accordingly, the provisions of this Book 1 apply only in the specific contexts defined in the other Books. The other Books, in making reference to any of the sections in this Book 1, specify the extent to which that section is applicable. The other Books may also include additional requirements as necessary.

1.3 Conformance and references

1.3.1 Conformance

All provisions in the Zhaga interface specifications are mandatory, unless specifically indicated as recommended, optional or informative. Verbal expressions of provisions in the Zhaga interface specifications follow the rules provided in Clause 7 of ISO/IEC Directives, Part 2:2018. For all clarity, the word “shall” indicates a requirement that is to be followed strictly in order to conform to the Zhaga interface specifications, and from which no deviation is permitted. The word “should” indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

1.3.2 Normative references

[ANSI C78.377] American National Standard for electric lamps—Specifications for the Chromaticity of Solid State Lighting Products, ANSI NEMA ANSLG C78.377

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

[IEC TR 61341:2010] Method of measurement of centre beam intensity and beam angle(s) of reflector lamps

[IEC TR 62732]	Three-digit code for designation of colour rendering and correlated colour temperature
[IES LM-79-08]	IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products, IES LM-79-08
[NIST TN 1297]	NIST Technical Note 1297; 1994 Edition—Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results
[Zhaga-ECG]	Zhaga Interface Specification, Book 13 Separate Electronic Control Gear
[LEDset-Inf]	LEDset1 Information Interface Specification, Edition 1.2, November, 2016 available from md-sig.org
[LEDset-Pow]	LEDset Power Interface Specification, Edition 1.1, November, 2016 available from md-sig.org

1.3.3 Informative references

[Zhaga LTLA]	Zhaga Logo Trademark License Agreement

1.4 Common definitions[11]

Ambient Temperature	Average temperature of the air in the environment where the Luminaire (or Test Fixture) is applied. A few typical examples are: • In case of an outdoor Luminaire or a suspended indoor Luminaire, the Ambient Temperature is the temperature of the air in the vicinity of the Luminaire. • In case of a recessed Luminaire, the Ambient Temperature is the temperature of the air in the room, below the ceiling and in the vicinity of the Luminaire.
Authorized Testing Center	Organization that is authorized by the Zhaga consortium to perform compliance tests for a specific Book.
Book	A Zhaga interface specification.
Built-in ECG	A Separate Electronic Control Gear that is designed for mounting inside an enclosure, such as provided by a Luminaire or a separate box. The use of a Built-in Electronic Control Gear outside a Luminaire without an enclosure can result in relevant standards for electrical product safety being violated.
Compatible	Two or more Zhaga products are Compatible if the combination can function as intended.
Demarcation	A component Demarcation is the boundary between the component and its environment.
Electronic Control Gear	A unit that is located between the external power and one or more LED Modules to provide the LED Module(s) with an appropriate voltage or current. It may consist of one or more separate components, and may include additional functionality, such as means for dimming, power factor correction, and radio interference suppression.
External Power	The electrical power that is supplied to the LED Light Engine. Typically this is the mains power, but it can also be from another source like a battery or an application specific power grid.
Holder	A component that maintains the LED Light Engine, the LED Module or the LED Array in a functional position, and

11 The definitions are possibly further restricted in the other Zhaga Books.

	establishes electrical contact with the LED Light Engine, LED Module or LED Array.
Independent ECG	An ECG consisting of one or more separate elements so designed that it can be mounted separately outside the luminaire, with protection according to the marking of the ECG and without any additional enclosure. This may consist of a Built-in ECG housed in a suitable enclosure which provides all the necessary protections according to its marking.
Integrated ECG	An ECG of a LLE that is accommodated in the same housing as the LED module(s) of the LLE. This combination is an Integrated LED Light Engine.
Integrated LED Light Engine	A LED Light Engine that consists of a single housing. This is the same as a “LED Light Engine with Integrated ECG”. Note that a module, complying with a specific Book that describes a LLE with Separate ECG but that is directly connected to external power would be an Integrated LLE and thus would be out of scope of that Book.
Interchangeable	Two Zhaga products are Interchangeable if replacement of the first product with the second product in a system results in comparable photometric and dimming properties of that system.
LED Array	A light source that is supplied as a single unit and intended to be used in combination with a Holder. In addition to one or more LEDs, their mechanical support and their electrical connection, it may contain components to improve its photometric, thermal, mechanical and electrical properties, but it does not include the Electronic Control Gear.
LED Light Engine	A combination of one Electronic Control Gear and one or more LED Modules and means for interconnecting these components. A LED Light Engine may consist of multiple housings.
LED Module	A light source that is supplied as a single unit. In addition to one or more LEDs, their mechanical support and their electrical connection, it may contain components to improve its photometric, thermal, mechanical and electrical properties, but it does not include the Electronic Control Gear.
Light Emitting Surface	A surface of a LLE, LED Module or LED Array with specific dimensions, position and orientation through which the light is emitted.
Luminaire	A lighting fixture which provides an appropriate environment for one or more LLEs and possibly other components.
Luminaire Optics	Set of one or more optical elements, which shape the lightoutput of the LLE, not being part of the LLE itself.
Measurement Uncertainty	Measurement Uncertainty is the same as “expanded uncertainty” as defined in [NIST TN 1297].
Optics Contact Area	Physical surface in the LLE or LED Module with a defined shape and position which allows for a stable and functional positioning of the Luminaire Optics on the LLE or LED Module.
Product Data Set	The combined data in the product data sheet, product label and other public documents related to the product.

Rated <parameter>	The value of the <parameter> as listed in the Product Data Set. Examples: the Rated voltage, the Rated frequency, etcetera.
Rated Operating Temperature	Value of the operating temperature (t_r *or* t_p) at which the Rated LLE, LED Module or LED Array values are specified.
Reference Temperature	The temperature at a specified position on the Thermal Interface Surface under steady state operating conditions. The exact coordinates of this position are defined for each type of LLE or LED Module in the respective Book.
Relative Partial Luminous Flux	Percentage of the luminous flux that is emitted by a light source into the rotationally symmetric solid angle bounded by two polar angles (see also section 4.4).
Separate ECG	An ECG of an LLE that is accommodated in a housing that is separate from the LED module(s) of the LLE.
Test Engine	A device that is used to define and measure properties of a Luminaire.
Test Fixture	A device that is used to define and measure properties of a LED Light Engine, a LED Module or a LED Array.
Thermal Interface Material	Material at the Thermal Interface Surface which has the purpose to improve the heat transfer from the LLE, LED Module or LED Array to the heat sink of the Luminaire.
Thermal Interface Surface	The surface of the LLE, LED Module, LED Array or Thermal Test Engine that makes physical contact with the surface of the heat sink of the Luminaire.
Zhaga Consumer Product.	A Zhaga Consumer Product is intended to be applied and replaced by consumers.
Zhaga Professional Product	A Zhaga Professional Product is intended to be applied by a Luminaire maker.

1.5 Common acronyms

ATC Authorized Testing Center
CCT correlated color temperature
CRI color rendering index
DUT device-under-test
ECG Electronic Control Gear
LED light emitting diode
LES Light Emitting Surface
LLE LED Light Engine
NA not applicable
OCA Optics Contact Area
PETF Photometric & electrical Test Fixture
PCB printed circuit board
PDS Product Data Set
RMS root mean square
TIM Thermal Interface Material
TIS Thermal Interface Surface
TPTF thermal power Test Fixture
TTE thermal Test Engine
TUTF thermal uniformity Test Fixture

1.6 Common symbols

P_{el} Electrical power consumed by the LLE (unit: W).

$P_{el,mod}$ Electrical power consumed by the LED Array or LED Module (unit: W).

P_{vis} Radiant flux of the LLE, LED module or LED Array in the wavelength range from 380nm up to 780nm (unit: W).

P_{th} Thermal power generated in the LLE, LED Module or LED Array (unit: W).

$P_{th,rear}$ Thermal power that is drained from the LLE, LED Module or LED Array through the Thermal Interface Surface (unit: W).

$P_{th,front}$ Thermal power that is drained from the LLE, LED Module or LED Array by convection and IR radiation (unit: W).

R_{th} Thermal resistance from the Thermal Interface Surface to the environment (unit: K/W).

$R_{th,max}$ Value of the thermal resistance from the Thermal Interface Surface to the environment for which holds: $t_r = t_{r,rated}$ (unit: K/W).

$R_{sp}(i,j)$ Thermal spreading resistance between measurement points i and j (unit: K/W).

R_{sp}^{max} Maximum thermal spreading resistance (unit: K/W).

$SPD(\lambda)$ Spectral Power Distribution (unit: W/nm). $SPD(\lambda)$ corresponds to what is expressed as “total spectral radiant flux” in [IES LM-79-08].

t_a Ambient Temperature (unit: °C).

t_p The temperature at a specified point on the LLE, LED Module or LED Array under steady state operating conditions (unit: °C). The exact position of this measurement point is defined for each product in its PDS.

t_r The temperature at a specified point on the Thermal Interface Surface of the LLE, LED Module or LED Array under steady state operating conditions (unit: °C). The exact coordinates of this position are defined for each type of LLE, LED Module or LED Array in the respective Book.

$t_{r,max}$ Rated Operating Temperature (unit: °C) (Used in earlier editions of the specifications; replaced by $t_{r,rated}$).

$t_{r,rated}$ Rated Operating Temperature related to t_r (unit: °C).

$t_{p,rated}$ Rated Operating Temperature related to t_p (unit: °C).

1.7 Common conventions

1.7.1 Cross references

Unless indicated otherwise, cross references to sections in either this document or documents listed in section 1.3, refer to the referenced section as well as the sub sections contained therein.

1.7.2 Informative text

With the exception of sections that are marked as informative, informative text is set in italics.

1.7.3 Terms in capitals

All terms starting with a capital are defined in section 1.4.

1.7.4 Units of physical quantities

Physical quantities are expressed in units of the International System of Units.

1.7.5 Decimal separator

The decimal separator is a comma (“,”).

2 Overview of Zhaga (informative)

2.1 About Zhaga

Zhaga has created a set of interface specifications, known as Books, which define the interfaces between a LED Luminaire component and its environment. Examples of LED Luminaire components are LED Light Engines, LED Modules, LED Arrays, Holders, Electronic Control Gears (LED drivers) and connectivity fit systems. The Zhaga Consortium aims to facilitate easy exchange of components in a LED Luminaire. Replacement may be attractive because of superior characteristics of the new component featuring new technology or for second source choices for optimizing the logistic process or simply to be open for more cost effective alternatives. Another important use case is the replacement of a component by another one with (photometric) properties that better fit a new application. The replacement of components is facilitated by defining the following interfaces between the component and its environment:

- mechanical interface
- photometric interface
- electrical interface
- thermal interface
- control interface

Apart from definitions of the interfaces listed above, each Zhaga book also defines requirements for the information in the Product Data Set (section 2.4).

A Zhaga interface specification defines either a Zhaga Professional Product or Zhaga Consumer Product. A Zhaga Professional Product is intended to be applied by a Luminaire maker while a Zhaga Consumer Product is intended to be applied and replaced by consumers.

The Zhaga interface specifications do not define safety requirements (electrical, thermal etcetera) of Zhaga products. There may be a recommendation to specify in the Product Data Set of the LLE, LED Module or LED Array the implemented electrical insulation.

Note that a LED Luminaire component which is defined in a Book may be categorized in that Book, for example in categories having different dimensions, different external powers or different Optics Contact Areas.

2.2 Zhaga building blocks and interfaces

In this section, the definitions of Zhaga building blocks are elaborated. Each Book defines interfaces between a LED Luminaire component and its environment (see section 2.1).

In the context of the Zhaga interface specifications, a Luminaire is a lighting fixture which provides an appropriate environment for one or more LED Light Engines and possibly other components (see Figure 2-1 and Figure 2-2). A Luminaire typically (but not necessarily) is comprised of a heat sink to carry away the heat generated in the LLE(s), optical devices to reshape the light beam of the LLE(s), means to supply electrical power to the LLE(s), connectivity fit system to attach an extension module to the Luminaire and means to attach the Luminaire to a wall, ceiling, stand, etcetera.

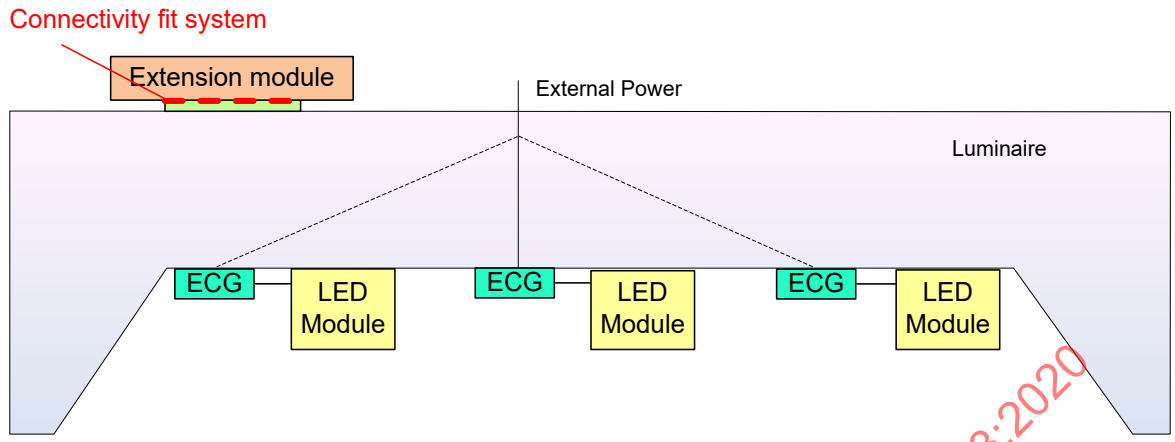

Figure 2-1 – Schematic overview of a Luminaire and one or more non-integrated LED Light Engines

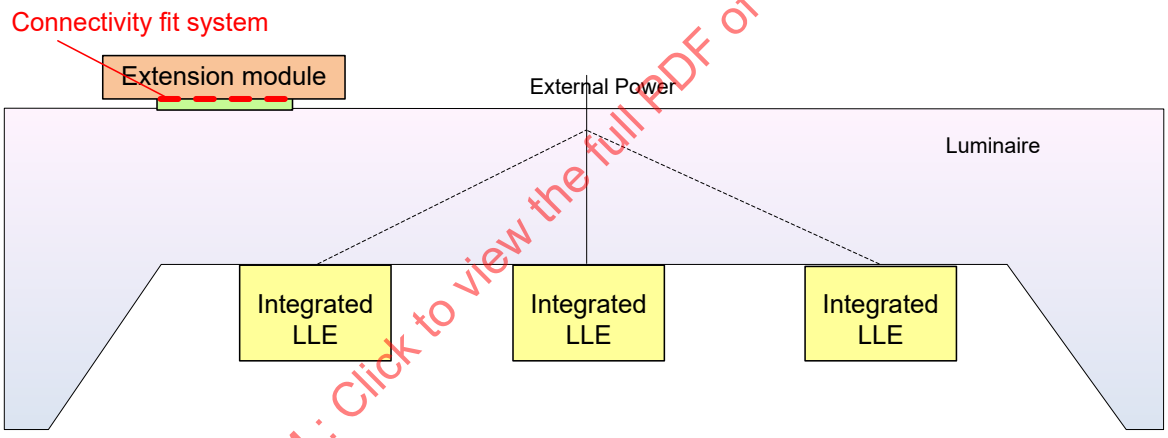

Figure 2-2 – Schematic overview of a Luminaire and one or more integrated LED Light Engines

A LED Light Engine is defined as a combination of one Electronic Control Gear and one or more LED Modules (see Figure 2-3 and Figure 2-4).

A LED Module is defined as a light source that is supplied as a single unit. In addition to one or more LEDs, their mechanical support and their electrical connection, it may contain components to improve its optical, thermal, mechanical and electrical properties, but it does not include the Electronic Control Gear.

The Electronic Control Gear is defined as a unit that is located between the External Power and one or more LED Modules to provide the LED Module(s) with an appropriate voltage or current. It may consist of one or more separate components, and may include additional functionality, such as means for dimming, power factor correction, and radio interference suppression.

The LED Module(s) and the Electronic Control Gear can be in one housing as depicted in Figure 2-3. Such a system is denoted as a LED Light Engine with Integrated ECG, or alternatively as an Integrated LED Light Engine.

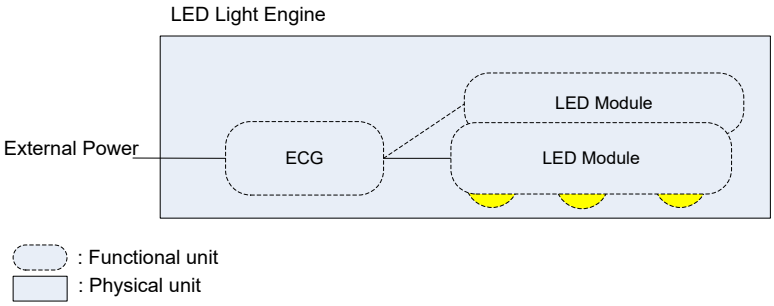

Figure 2-3 – Schematic overview of a LED Light Engine with Integrated ECG

Alternatively, the LED Light Engine consists of an Electronic Control Gear and one or more LED Modules in separate housings as depicted in Figure 2-4. Such a system is denoted as a LED Light Engine with Separate ECG.

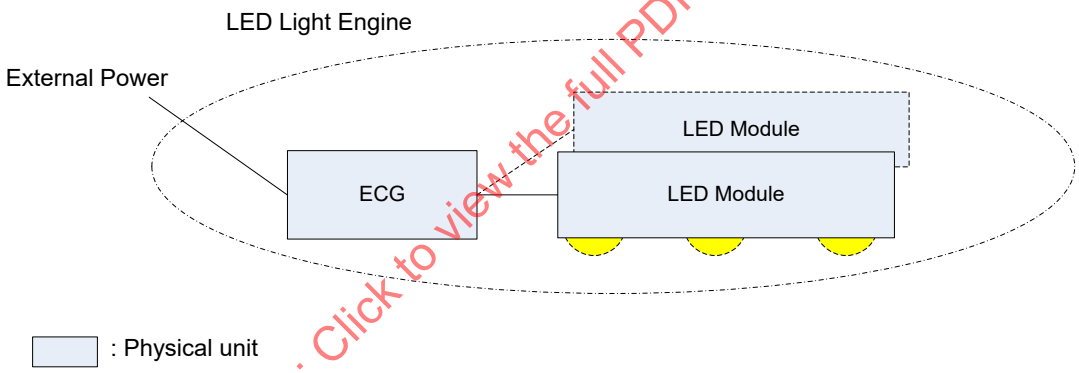

Figure 2-4 – Schematic overview of a LED Light Engine with Separate ECG

2.3 Compatibility and Interchangeability

The Zhaga Consortium aims to define LED Luminaire components which are Interchangeable in the sense that LED Luminaire components, possibly designed by different manufacturers, can be interchanged without complications. Practically speaking this means that a professional lighting expert can replace one component by another one while maintaining essentially the same functionality. The Zhaga defines two concepts which are relevant in this context: Compatibility and Interchangeability:

- Two Zhaga products are Compatible if the combination can function as intended.
- Two or more Zhaga products are Interchangeable if replacement of the first product with the second product in a system results in comparable photometric and dimming properties of that system.

Note that to ensure Interchangeability, the Luminaire also should be designed for Interchangeability. As an example, the Luminaire Optics should incorporate diffusing elements to account for different granularity of light emission by different LLEs or different LED Modules.

2.4 Product Data Set

The Product Data Set is defined as the combined data in the product data sheet, product label and other public documents related to the product. The requirements with respect to the Product Data Set of a Zhaga product are defined in the applicable Book. These requirements guarantee that the Product Data Sets of Zhaga products contain the information which

- enables a check on Compatibility and
- enables a prediction of the (photometric) properties of a combination of Zhaga products.

2.5 Compliance testing

As an example one manufacturer brings to the market a Zhaga certified product A while another manufacturer brings to the market a Zhaga certified product B. At a later point in time, a professional lighting expert may combine product A and product B in a Luminaire (product C) for a specific application.

One of the challenging issues is that the characteristics of the product A-B-C combination in terms of performance and lifetime depend on the characteristics of all three products and on how these three sets of characteristics match. In order to effectively cope with this situation, Zhaga has defined procedures with tests to be conducted by manufacturers and Authorized Testing Centers and checks to be conducted by the one who intends to use these products. The checks are described in section 2.6 while the test related procedures are described in sections 2.5.1 and 2.5.2.

2.5.1 Certification

Before market introduction of a Zhaga product, the following procedure is conducted. See also Figure 2-5.

- Next to measurements and tests that may be required for internal purposes and regulations, the manufacturer of a Zhaga product performs all measurements that are needed to generate the Product Data Set that is required by the Zhaga interface specification. The measurements are performed as defined in the Zhaga interface specification. The outcome of these tests is laid out in the Product Data Set that is provided with the product.
- The manufacturer sends the product with associated Product Data Set to an Authorized Testing Center. The ATC performs all compliance tests that are listed in the corresponding Zhaga Book and returns a test report and a test report summary to the manufacturer.
- The manufacturer sends the test report summary to the Zhaga Logo License Administrator. If the test report summary indicates that the product has passed all tests, the Zhaga Logo License Administrator certifies the product.

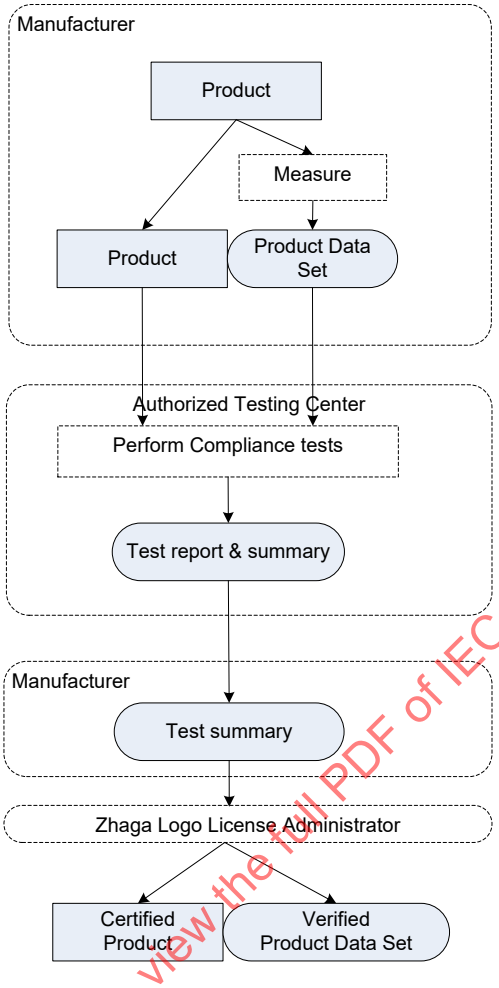

Figure 2-5 – Overview of test and certification of Zhaga products

2.5.2 Market surveillance

After market introduction of a Zhaga product, a market surveillance procedure may be initiated to check for the compliance of the product. For details on the market surveillance procedure and consequences of non-compliance see [Zhaga LTLA].

2.6 Compatibility check

Using the Product Data Set of the Zhaga certified products, the Luminaire maker or, for some LLEs the end-user, can check whether two or more Zhaga products are Compatible.

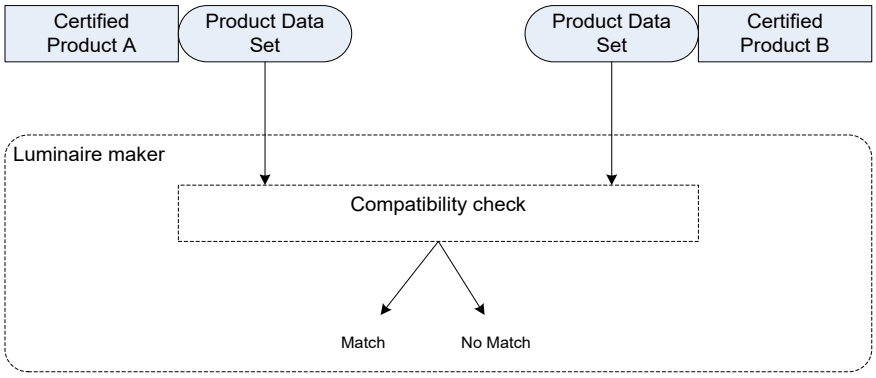

Figure 2-6 – Compatibility check

2.7 Zhaga product certification

The Zhaga Consortium prohibits use of its trademark on products and on product documentation without a trademark license. Members can obtain a conditional trademark license by signing the so-called Zhaga Logo Trademark License Agreement [LTLA]. This agreement licenses the Zhaga Logo for use on products that have certified.

3 Mechanical interface

3.1 Drawing principles

Unless indicated otherwise, the characteristics of the mechanical interface are specified according to the following principles:

- The dimensions are in millimeters.
- 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.

3.2 Mechanical interface between Separate ECG and Luminaire

The mechanical interface between the Separate ECG and the Luminaire is defined in [Zhaga-ECG].

3.3 Thermal expansion

The mechanical dimensions are verified at a temperature in the range 25 ± 5 ℃. This is the temperature at which a LED Luminaire component is typically mounted in a Luminaire. Manufacturers should take all necessary measures to ensure that thermal expansion or contraction is accommodated for the complete operating temperature range.

3.4 Demarcation (Informative)

In many Zhaga books the mechanical interface of a product, for example a LED Module, a LED array, an LLE or an ECG has been defined by means of a so-called Demarcation model. In this section the principle of the Demarcation model will be elaborated by means of an example.

Figure 3-1 – Example of a Demarcation Model (2-dimensional)

A demarcation model defines a 3-dimensional space. The product shall fit in this space and at the same time the environment of the product (generally the luminaire) shall not intrude this space.

Figure 3-1 shows a Demarcation model. For simplicity, this is a 2-dimensional model rather than a 3-dimensional model but the principle is exactly the same. The green area is the keep-in zone for the product and the keep-out zone for the product's environment. It shows that the product can have any shape as long as it does not cross the outline and it does not cross the boundaries of the screw holes. It also shows that the Luminaire, including screws can have any shape as long as it does not cross the outline and it does not cross the boundaries of the screw holes.

Figure 3-2 shows an example of a product that is compliant with the demarcation model.

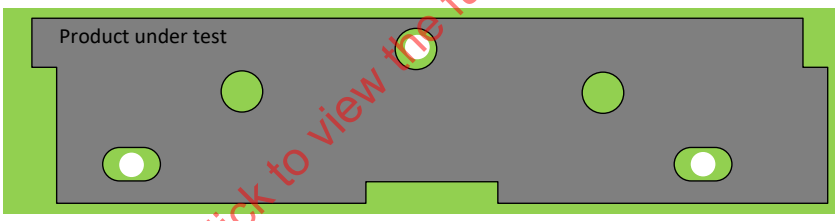

Figure 3-2 – Example of a product which is compliant with the Demarcation Model

Figure 3-3 and Figure 3-4 show two examples of products that do not comply with the Demarcation model.

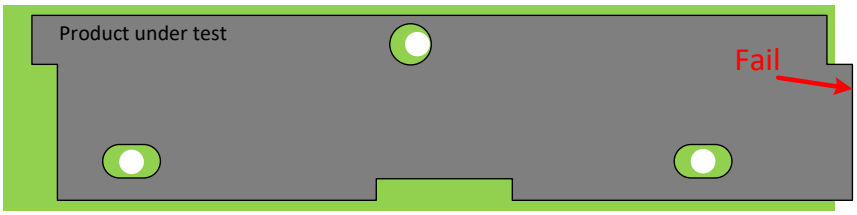

Figure 3-3 – Example of a product which is not compliant with the Demarcation Model

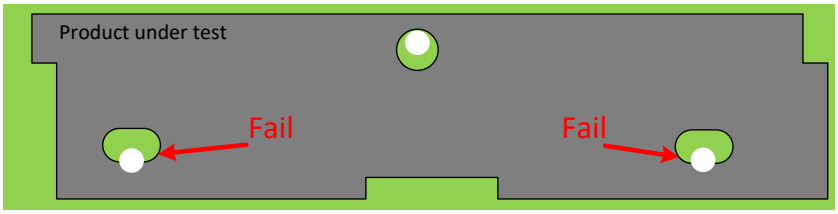

Figure 3-4 – Example of a product which is not compliant with the Demarcation Model

Guidelines for measuring compliance with the Demarcation model are provided in Annex B.

4 Photometric interface

4.1 Light Emitting Surface

A Light Emitting Surface (LES) is a surface associated to a LED Light Engine or a LED Module/LED Array with specific dimensions, position and orientation through which the light is emitted and that has the following characteristics:

- All substantial light generated by the LED Light Engine or the LED Module/LED Array is emitted through this surface.
- The center of the Light Emitting Surface coincides with the reference point of the luminous intensity distribution (See Figure 4-1).
- The LES is generally described by simple a geometrical shape, for example a circle or a rectangle. It has a physical boundary or is a virtual surface in the surrounding area of the LLE or the LED Module/LED Array.

(Informative)
For each type of LLE or LED Module/LED Array the definition of the LES may be further restricted in the respective Book according to the following principles:

- *When seen along the axis perpendicular to the LES, all parts of the light emitting area (LEDs, diffuse cover and/or mixing chamber) are covered by the LES.*
- *The position of the LES is chosen in a way, that all light emitting parts are behind the LES, when seen along the axis perpendicular to the LES.*
- *Inside a circular shaped LES, the LEDs may be placed in any arrangement, for example in a rectangular arrangement.*
- *A clear dome or cover above one or more LEDs is allowed to exceed the LES height.*

Examples LES definitions:

- *The LES is the domed cover of a multichip, phosphor covered LLE or LED Module/LED Array.*
- *The LES is a circle or a rectangle which is large enough to encompass all silicone domes of packaged LEDs in the LLE or LED Module/LED Array completely.*
- *In case the LEDs are encircled by the nearly vertical walls of a light guiding, mixing or diffusing element, the LES is described by the opening of this element.*
- *In the case of a diffuse cover covering the LEDs, the LES is described by the light emitting area of the diffuse cover.*

For each type of LLE, LED Module or LED Array the requirements for the LES are defined in the respective Book.

4.1.1 LES categories

The Zhaga interface specifications define circular LES categories as listed in Table 4-1.

Table 4-1 – Definition of circular LES categories

LES category designation	Minimum LES diameter[12]	Maximum LES diameter
LES6.3	4,5	6,3
LES9	6,3	9,0
LES13.5	9,0	13,5
LES19	13,5	19,0
LES23	19,0	23,0
LES30	23,0	30,0
LES40	30,0	40,0

4.2 Operating conditions for measuring photometric parameters

In general, the characteristics of the light generated by a LED Light Engine, a LED Module or a LED Array depend on the operating conditions. This section defines the operating conditions that shall be applied when measuring the photometric parameters defined in this chapter.

In case the device-under-test is a LED Module or a LED Array the operating conditions for photometric tests shall be as follows:

- The LED Module/LED Array shall be mounted in Test Fixture PETF according to the manufacturer's mounting instructions.
- The LED Module/LED Array shall be connected to a power source according to the manufacturer's instructions. The input current and voltage shall be within 0,2 % of the Rated values.
- The ambient temperature shall be stable within the range 25 ± 1 °C.
- The heat sink of the test fixture shall maintain the temperature t_r *or* t_p within the range $t_{r,rated} \pm 1$ °C or $t_{p,rated} \pm 1$ °C respectively.
- The photometric output of the LED Module/LED Array shall not be affected in any way by objects (reflectors, glass or plastic windows, heat sink features, etcetera) that are exterior to the LED Module/LED Array and the Test Fixture.

In case the device-under-test is a LED Light Engine the operating conditions for photometric tests shall be as follows:

- The LLE or LED Module(s) in case of an LLE with Separate ECG shall be mounted in Test Fixture(s) according to the manufacturer's mounting instructions.
- The frequency of the External Power of the LLE shall be within 0,2 % of the Rated value. Depending on the Rated voltage range of the LLE, the LLE shall be tested at one or two values of the test voltage as indicated in Table 4-2.

12 The range of LES diameter values for a specific LES category is excluding the lower bound and including the upper bound. For example, a LES with a diameter of 9,0 mm shall have a designation LES9.

Table 4-2 – Test voltages for different Rated input voltages of the LLE

Rated voltage	Test voltage(s)
100…127	120 VAC
200…254	230 VAC
250…288	277 VAC
100…288	120 & 277VAC

- The ambient temperature shall be stable within the range 25 ± 1 ℃.
- The heat sink(s) of the test fixture(s) shall maintain the temperature t_r or t_p within the range $t_{r,rated} \pm 1$ ℃ or $t_{p,rated} \pm 1$ ℃ respectively.
- The photometric output of the LLE shall not be affected in any way by objects (reflectors, glass or plastic windows, heat sink features, etcetera) that are exterior to the LLE and the Test Fixture(s).
- In case of an LLE with Separate ECG, the ECG should be mounted at a distance from the LED Module such that the ECG does not influence the results of the measurement.
- In case of an LLE with Separate ECG, the LED Module(s) shall be electrically connected to the ECG according to the LLE manufacturer's instructions.
- In case the LLE features adjustable settings (for example output current of the ECG or de-rating settings), these settings shall be according to the manufacturer's instructions.
- In case of an LLE with Separate ECG and more than one LED Module, photometric properties shall be measured on one LED Module, while the other LED Modules are also operated according to the manufacturer's instructions to enable equal photometric output. If no instructions are provided, the other LED Modules shall be operated in environmental conditions equal to the conditions of the LED-Module-under-test. The measurement setup should be such that the light output of the other LED Modules has no effect on the measurement result.

4.3 Luminous flux

The Zhaga interface specifications define luminous flux categories as listed in Table 4-3. In case of an LLE with multiple LED Modules, luminous flux is defined per LED Module.

Table 4-3 – Definition of luminous flux categories

Luminous flux category	Minimum luminous flux [lm]	Typical luminous flux [lm]	Maximum luminous flux [lm]
100	90	100	150
150	135	150	250
250	225	250	350
350	315	350	500
500	450	500	800
800	720	800	1000
1000	900	1000	1500
1500	1350	1500	2000
2000	1800	2000	3000
3000	2700	3000	4000
4000	3600	4000	5000
5000	4500	5000	6000
6000	5400	6000	8000
8000	7200	8000	10000
10000	9000	10000	15000
15000	13500	15000	20000
20000	18000	20000	30000
30000	27000	30000	40000
40000	36000	40000	60000
60000	54000	60000	80000
80000	72000	80000	100000

4.4 Luminous intensity distribution

For each type of LLE, LED Module or LED Array, the required luminous intensity distribution may be defined in the respective Book. In case of a LLE with multiple LED Modules, the luminous intensity distribution is defined per LED Module.

The luminous intensity distribution may be defined in terms of Relative Partial Luminous Fluxes. The Relative Partial Luminous Flux is the percentage of the total luminous flux emitted into the rotationally symmetric solid angle bounded by the polar angles γ_1 and γ_2, as shown in Figure 4-1.

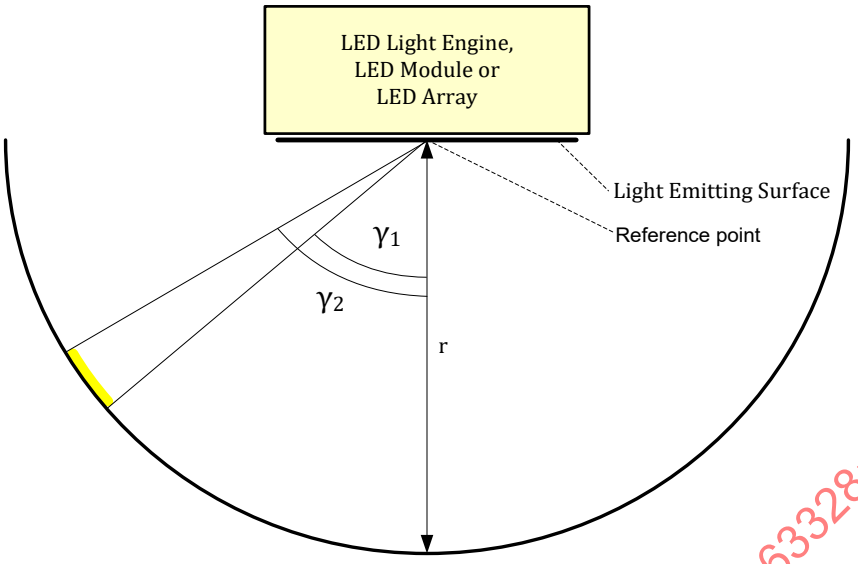

Figure 4-1 – Rotationally symmetric solid angle bounded by the polar angles γ_1 and γ_2 which is used to define the Relative Partial Luminous Flux

4.4.1 Beam angle and beam angle categories

The beam angle shall be defined as in [IEC TR 61341:2010] and the beam angle categories shall be defined as in Table 4-4.

Table 4-4 – Definition of beam angle categories

Beam angle category	Minimum beam angle (°)	Maximum beam angle (°)
6	3	9
12	9	15
17,5	15	21
25	21	29
35	29	41
55	41	70
90	70	110
120	110	150

4.5 Luminance uniformity

For each type of LLE, LED Module or LED Array, the required luminance characteristics may be defined in the respective Book. In case of a LLE with multiple LED Modules, luminance characteristics are defined per LED Module.

4.6 Correlated color temperature (CCT)

The CCT category of an LLE, LED Module or LED Array shall comply with the provisions of [ANSI C78.377], with the exception that the target color points may be chosen freely within the quadrangles defined therein. Only the nominal CCT categories as specified in [ANSI C78.377] shall be used. The value, in combination with the CRI value shall be expressed using the three-digit code as defined in [IEC TR 62732]. In case of an LLE with multiple LED Modules, CCT is defined per LED Module.

4.7 Color rendering index (CRI)

The CRI value of the LLE, LED Module or LED Array is defined in [CIE 13.3]. The value, in combination with the CTT value shall be expressed using the three-digit code as defined in [IEC TR 62732]. In case of an LLE with multiple LED Modules, CRI is defined per LED Module.

4.8 Luminaire Optics (informative)

The Luminaire Optics (e.g. reflectors, refractors or diffusers) are not defined in the Zhaga interface specifications. It is recommended to design Luminaire Optics in such a way, that the nominal parameter values of the LES and luminous intensity distribution result in the desired photometric characteristics of the LLE-Luminaire Optics combination. Due to the compound nature of many LED Module solutions, it is expected that Luminaire Optics designed for Zhaga compliant LLEs takes into account the structure of LED clusters, e.g. by using frosted surfaces or facetted structures to achieve comparable light output with all kinds of module technologies enabled by the Zhaga interface specifications. The luminance uniformity of the LED Module can provide information on the measures that need to be taken to achieve proper light distributed with Luminaire Optics. The larger the uniformity the more simple the measures are that need to be taken for a proper light distribution.

5 Electrical interface

5.1 Electrical insulation (informative)

International and national regulations require that products on the market must be compliant with product safety standards (for example UL standards in the USA, EN standards in Europe and JIS-Standard and PSE-Law in Japan) and individual manufacturers are responsible for this.

The electrical insulation of a complete LLE-Luminaire system is a safety item and depends on the electrical insulation implemented in the components and in the Luminaire. Like all other safety requirements, electrical insulation is explicitly out of scope of the Zhaga interface specifications and it is the sole responsibility of the manufacturer that brings the product to the market.

6 Thermal interface

6.1 Background information (informative)

One of the most challenging issues in LED lighting is related to the temperature of the LED. On the one hand this component is made of a semiconductor material and therefore it is sensitive to operating temperature, both in terms of performance and lifetime. On the other hand the operating temperature of the LED is not only determined by the design of the LLE or the LED Module but also by the design of the Luminaire. Manufacturers of Zhaga LLEs or LED Modules have no knowledge in which Luminaire the LLE or LED Module will be used. In order to effectively cope with this situation, a model of LLE-Luminaire or LED Module-Luminaire combination with respect to thermal behavior is defined in this section. This thermal interface model allows prediction of the operating temperature t_r *or* t_p of a specific LLE – Luminaire combination or LED Module – Luminaire combination.

In section 6.2, the generic thermal interface model is defined whereas a simplified model is defined in section 6.3. The simplified model is applicable when a Luminaire maker applies a LLE or LED Module in a Luminaire.

6.2 Generic thermal interface model

6.2.1 General case

In the thermal interface model, the light generating (and heat generating) component can be any one of the following devices:

1) A LLE with Integrated ECG. In this case the thermal interface is defined as the contact surface of the LLE and the Luminaire.
2) A LED Module. In this case the thermal interface is defined as the contact surface of the LED Module and the Luminaire.
3) A LLE with Separate ECG. In this case the thermal interface is defined as the contact surface of the LED Module and the heat sink the Luminaire and it is assumed that the ECG does not influence the thermal behavior of the Luminaire – LLE combination (See also section 6.1.12). In case of an LLE with multiple LED Modules, each LED Module has its thermal interface with the Luminaire.

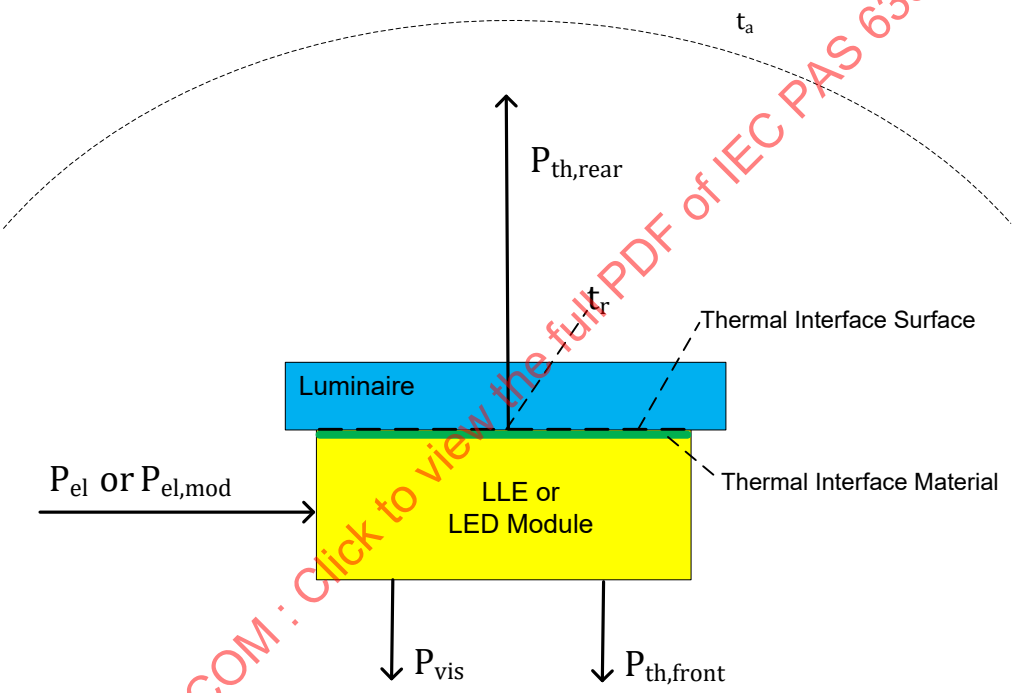

Figure 6-1 – Thermal model of a LLE – Luminaire or a LED Module – Luminaire combination

Figure 6-1 illustrates the model of the thermal interface between the LLE or LED Module and the Luminaire. The LLE or LED Module consumes an amount of electrical power P_{el} and $P_{el,mod}$ respectively. This power is converted into visible light and heat:

$$\boldsymbol{P}_{el} = \boldsymbol{P}_{vis} + \boldsymbol{P}_{th} \quad \text{or} \quad \text{EQ. 6-1}$$

$$P_{el,mod} = P_{vis} + P_{th} \quad \text{EQ. 6-2}$$

Here, P_{vis} is defined as the radiant flux in the visible light spectrum (380 nm< λ < 780 nm)[13].

[13] IR radiation is not included in P_{vis} and it is assumed that radiation in the range λ < 380 nm is negligible.

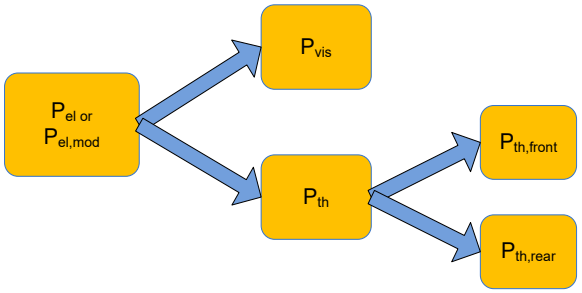

Figure 6-2 – Power conversion

Some of the thermal power P_{th} is drained by convection and infra-red radiation. The sum of the thermal power drained by convection and IR radiation is denoted by $P_{\text{th,front}}$[14]. Typically a substantial part of the thermal power will be drained through the Thermal Interface Surface to the heat sink of the Luminaire[15]. This portion is denoted by $P_{\text{th, rear}}$.

$$P_{\text{th}} = P_{\text{th,rear}} + P_{\text{th,front}} \qquad \text{EQ. 6-3}$$

The Thermal Interface Surface is defined as the surface of the LLE or LED Module that makes physical contact with the surface of the heat sink of the Luminaire. The temperature t_{r} is defined as the temperature at a specified position on the Thermal Interface Surface under steady state operating conditions[16]. The exact position of this temperature point is defined for each type of LLE or LED Module in the respective Book.

The Zhaga defines the Rated Operating Temperature ($t_{\text{r,max}}$) and the value of $t_{\text{r,max}}$ shall be such that if $t_{\text{r}} = t_{\text{r,max}}$, a sample of the LLE or LED Module at zero burning hours shows photometric values equal to the Rated values within tolerances defined in the compliance test specifications of the Zhaga interface specifications.

The Reference Temperature t_{r} depends on the Ambient Temperature (t_{a}), the thermal resistance of the heat sink of the Luminaire (R_{th}) and the thermal power that is transferred through the Thermal Interface Surface ($P_{\text{th,rear}}$). Using a simple 1-dimensional model, the following relation is obtained:

$$t_{\text{r}} = t_{\text{a}} + R_{\text{th}} \cdot P_{\text{th,rear}} \qquad \text{EQ. 6-4}$$

For performance equal to or better than the Rated values, the LLE or LED Module should be operated under the condition

$$t_{\text{r}} \leq t_{\text{r,max}} \quad \text{Or:}$$

$$R_{\text{th}} \leq R_{\text{th,max}} \qquad \text{with} \qquad R_{\text{th,max}} = \frac{t_{\text{r,max}} - t_{\text{a}}}{P_{\text{th,rear}}} \qquad \text{EQ. 6-5}$$

6.2.2 Test Fixture TPTF

The relation between the thermal power drained by convection and IR radiation ($P_{\text{th,front}}$) on the one hand and the thermal power drained via the heat sink ($P_{\text{th,rear}}$) on the other hand depends

14 $P_{\text{th,front}}$ is defined to be the thermal power that is drained by convection and IR radiation to the environment and not re-absorbed by the LLE, the LED Module or the heat sink.

15 Heat transfer via conduction through other parts of the system is assumed to be negligible.

16 “steady state” is defined in section A.1.3.5.

on the geometry of the LLE-Luminaire system or the LED Module–Luminaire system. For each type of LLE or LED Module a Test Fixture TPTF may be defined in the respective Book. This Test Fixture TPTF shall be used to measure $P_{\text{th,rear}}$.

6.2.3 Rated Operating Temperature and safety (informative)

The Rated Operating Temperature ($t_{r,rated}$) or ($t_{p,rated}$) is used to define the conditions for the measurement of the temperature dependent parameters of the LED Light Engine or LED Module. In practical applications the Reference Temperature may be higher or lower than the Rated Operating Temperature. Also, the Rated Operating Temperature is not the absolute maximum temperature related to safety.

In order to comply with safety regulations, the LLE manufacturer has to make sure that the LLE or LED Module operates safely under normal operating conditions. However this is not mandated by Zhaga and will not be verified by the ATC. In typical products the maximum temperature related to safety will be considerably higher than the Rated Operating Temperature ($t_{r,rated}$) or ($t_{p,rated}$). This maximum temperature related to safety may be listed in the Product Data Set of the LLE or the LED Module/LED Array. Alternatively the LLE or LED Module/LED Array manufacturer may specify the maximum thermal resistance related to safety in the Product Data Set.

6.2.4 Thermal overload protection (Informative)

The temperature t_r or t_p in a specific LLE-Luminaire or LED Module-Luminaire combination depends on many characteristics of the LLE or the LED Module, the Luminaire and the mounting (for example the TIM and the contact pressure). Zhaga does not mandate a protection in the LLE or LED Module that guarantees the temperature t_r or t_p not to exceed an upper limit (for example by reducing power or shut down).

6.2.5 Ambient Temperature

As indicated in EQ. 6-5, the maximum thermal resistance of the LLE or LED Module ($R_{\text{th,max}}$) depends on the Ambient Temperature. With increasing Ambient Temperature $R_{\text{th,max}}$ decreases. This effect can be significant and shall be taken into account in the thermal compatibility check (section 6.2.7).

The LLE or LED Module manufacturer may list values of $R_{\text{th,max}}$ for several values of the Ambient Temperature. For each type of LLE or LED Module, Product Data Set requirements with respect to $R_{\text{th,max}}$ are defined in the respective Book. In case the Ambient Temperature is not listed in the Product Data Set, a value of 25 °C shall be used.

For each type of LLE or LED Module it is defined in the respective Book whether the Ambient Temperature shall be listed on the Luminaire Product Data Set or not.

In case the Ambient Temperature is listed in the Product Data Set of the Luminaire this value shall be used in the thermal compatibility check (section 6.2.7) to determine the corresponding $R_{\text{th,max}}$ of the LLE or the LED Module.

In case the Ambient Temperature is not listed in the Product Data Set of the Luminaire an independent judgment of the Ambient Temperature shall be made and this value shall be used in the thermal compatibility check (section 6.2.7) to determine the corresponding $R_{\text{th,max}}$ of the LLE or LED Module.

6.2.6 Luminaires with multiple LLEs or multiple LED Modules

Within Zhaga, a Luminaire is a lighting fixture which provides an appropriate environment for one or more LED Light Engines. Each LED Light Engine is a combination of one Electronic Control Gear and one or more LED Modules. In this section two cases for Luminaires with multiple LLEs or Multiple LED Modules are described.

6.2.6.1 Separate heat sinks

In case a Luminaire contains more than one LLE or more than one LED Module and these LLEs or LED Modules are mounted on separate heat sinks, it is assumed that the LLEs or LED Modules do not influence each other from a thermal point of view. The general model described in section 6.2.1 can be applied to each LLE or LED Module individually.

6.2.6.2 One heat sink

In case a Luminaire contains more than one LLE or more than one LED Module and these LLEs or LED Modules are mounted on a single heat sink, all LLEs or LED Modules shall be identical[17]. For such systems, the thermal resistance of the Luminaire is defined as:

$$R_{\text{th}} = \frac{MAX\,(t_{\text{r,i}}) - t_{\text{a}}}{P_{\text{th,rear}}} \qquad \text{EQ. 6-6}$$

with $t_{\text{r,i}}$: temperature t_{r} of a LLE$_{\text{i}}$ or LED Module$_{\text{i}}$

$P_{\text{th,rear}}$: Thermal power per LLE or LED Module

6.2.7 Thermal compatibility check

In general, the thermal resistance of a heat sink depends on the thermal power applied to the Thermal Interface Surface ($P_{\text{th,rear}}$). For that reason several values of $P_{\text{th,rear}}$ and corresponding values of R_{th} are listed on the Product Data Set of the Luminaire.

In order to determine whether a particular LLE or LED Module is thermally compatible[18] with a particular Luminaire, it should be verified that the applicable thermal resistance R_{th} specified in the Product Data Set of the Luminaire is less than or equal to the applicable maximum thermal resistance $R_{\text{th,max}}$ specified in the Product Data Set of the LLE or LED Module. Here, the applicable thermal resistance can be linearly approximated from thermal resistances corresponding to thermal powers above and below the actual LLE or LED Module thermal power. In cases of doubt or incomplete data, the thermal resistance of a power lower than the actual LLE or LED Module power shall be chosen for evaluation. The applicable maximum thermal resistance $R_{\text{th,max}}$ is the maximum thermal resistance that corresponds with the Ambient Temperature.

As an example (Informative), consider the information listed in the Product Data Sets of particular LLEs and Luminaires:

17 In case a Luminaire contains more than one LLE or more than one LED Module/LED Array and these LLEs or LED Modules/LED Arrays are mounted on the same heat sink the temperature t_{r} of each LLE or LED Module/LED Array depends on the characteristics of all LLEs or LED Modules/LED Arrays and on the geometry of the system. In general this will result in a complex dependency matrix that cannot be translated into a simple model characterized by one thermal resistance (R_{th}). For that reason the model has been restricted to Luminaires with identical LLEs or LED Modules/LED Arrays. In later editions of the document the model may be expanded to other configurations.

18 "thermally compatible" means that the LLE-Luminaire or LED Module/LED Array-Luminaire combination will operate at $t_{\text{r}} \leq t_{\text{r,max}}$.

Data sheet of LLE #1				
$t_{r,max}$ (°C)	65			
$P_{th,rear}$ (W)	18			
ta (°C)		30	40	50
$R_{th,max}$ (K/W)		1.9	1.4	0.8

Data sheet of LLE #2				
$t_{r,max}$ (°C)	80			
$P_{th,rear}$ (W)	35			
ta (°C)		30	40	50
$R_{th,max}$ (K/W)		1.4	1.1	0.9

Data sheet of Luminaire #1		
Max. ta (°C)		30
R_{th} at $P_{th,rear}$ = 10 W (K/W)		1.8
R_{th} at $P_{th,rear}$ = 20 W (K/W)		1.6
R_{th} at $P_{th,rear}$ = 30 W (K/W)		1.5
R_{th} at $P_{th,rear}$ = 40 W (K/W)		1.4

Data sheet of Luminaire #2		
Max. ta (°C)		40
R_{th} at $P_{th,rear}$ = 10 W (K/W)		0.9
R_{th} at $P_{th,rear}$ = 20 W (K/W)		0.8
R_{th} at $P_{th,rear}$ = 30 W (K/W)		0.7
R_{th} at $P_{th,rear}$ = 40 W (K/W)		0.6

From these numbers it can be concluded that

- *LLE #1 is thermally compatible with Luminaire #1 as R_{th} at $P_{th,rear} = 10$ W (1,8 K/W) is less than $R_{th,max}$ at 30 °C (1,9 K/W)*
- *LLE #1 is thermally compatible with Luminaire #2 as R_{th} at $P_{th,rear} = 10$ W (0,9 K/W) is less than $R_{th,max}$ at 40 °C (1,4 K/W)*
- *LLE #2 is not thermally compatible with Luminaire #1 as R_{th} at $P_{th,rear} = 30$ W (1,5 K/W) is more than $R_{th,max}$ at 30 °C (1,4 K/W)*
- *LLE #2 is thermally compatible with Luminaire #2 as R_{th} at $P_{th,rear} = 30$ W (0,7 K/W) is less than $R_{th,max}$ at 40 °C (1,1 K/W)*

6.2.8 Thermal uniformity

The thermal interface model defined in section 6.2.1 is a one-dimensional model. Implicitly it is assumed that the temperature across the Thermal Interface Surface is independent of the position. In typical applications this is not exactly the case. When replacing the LED Light Engine or LED Module by a Thermal Test Engine, the thermal interface model can only be used to predict the temperature t_r if the temperature non-uniformity of the LED Light Engine or LED Module and the Thermal Test Engine are limited. The non-uniformity of the temperature distribution across the Thermal Interface Surface depends on:

- the construction of the TTE, LLE, or LED Module and
- the construction of the heat sink of the Luminaire.

The non-uniformity of the temperature distribution across the Thermal Interface Surface is expressed in a set of thermal spreading resistance values. Here, the thermal spreading resistance between two measurement points i and j is defined as:

$$R_{\mathrm{sp}}(i,j) = \frac{t_i - t_j}{P_{\mathrm{th,rear}}} \qquad \text{EQ. 6-7}$$

Here t_i and t_j are the temperatures at the measurement points i and j located on the Thermal Interface Surface. For each type of LLE or LED Module/LED Array the positions of these measurement points may be defined in the respective Book.

The parameter $R_{\mathrm{sp}}^{\max}$ is defined as the maximum value of all spreading resistance values:

$$R_{\mathrm{sp}}^{\max} = MAX(R_{\mathrm{sp}}(i,j)) \qquad \text{EQ. 6-8}$$

The Zhaga interface specification may restrict the thermal non-uniformity in the case of a LLE or LED Module being operated in a Test Fixture TUTF. For each type of LLE or LED Module the Test Fixture TUTF and the requirements for thermal uniformity in this test case may be defined in the respective Book.

6.2.9 Thermal Interface Material

In order to guarantee good thermal contact between the LLE or LED Module/LED Array and the heat sink, a Thermal Interface Material (TIM) is typically applied to this interface. The TIM is defined to be part of the LLE or LED Module/LED Array and the Thermal Interface Surface is at the interface of the Luminaire and the TIM as depicted in Figure 6-3.

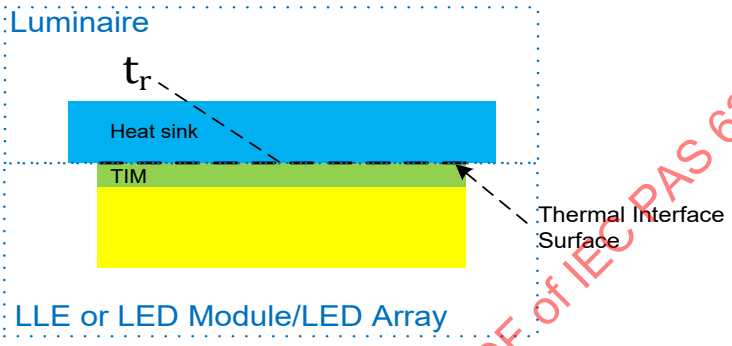

Figure 6-3 – Position of the Thermal Interface Surface in case of a configuration with TIM

The LLE or LED Module/LED Array shall be tested with the TIM prescribed by the LLE or LED Module/LED Array manufacturer, and the LLE or LED Module/LED Array manufacturer shall provide the prescribed TIM to the Zhaga Authorized Testing Center (ATC) when offering the LLE or LED Module/LED Array for Zhaga compliance testing. The Luminaire shall be tested with a TIM that is specified in the test specification of the respective Book.

6.2.10 Surface planarity and roughness

In order to guarantee good thermal contact between the LLE or LED Module/LED Array and the heat sink of the Luminaire, both the surface of the LLE or LED module/LED Array and the surface of the heat sink shall meet planarity and roughness requirements. For each type of LLE or LED Module/LED Array these requirements may be defined in the respective Book.

6.2.11 Aging of LED Light Engine or LED Module/LED Array (informative)

Due to aging of the LED, the radiated power (P_{vis}) will decrease over time and consequently the thermal power will increase. Although this effect is relatively weak it is recommended that the Luminaire manufacturer takes it into account in the design of the Luminaire.

6.2.12 Empty

This section is empty because its contents in a previous version has become obsolete.

6.2.13 Ambient Temperature and thermal resistance (R_{th})

The Ambient Temperature is defined as the average temperature of the air in the environment where the Luminaire (or Test Fixture) is applied. A few typical examples are:

- In case of an outdoor Luminaire or a suspended indoor Luminaire, the Ambient Temperature is the temperature of the air in the vicinity of the Luminaire.
- In case of a recessed Luminaire, the Ambient Temperature is the temperature of the air in the room, below the ceiling and in the vicinity of the Luminaire.

In section 6.2.1, the thermal resistance of the Luminaire (R_{th}) is defined as the thermal resistance from the Thermal Interface Surface to the environment. The environment corresponds to the position where the Ambient Temperature is defined.

As a consequence of these definitions, the thermal resistance of the Luminaire (R_{th}) depends on the mounting conditions of the Luminaire. The Luminaire manufacturer defines in the PDS (generally in the mounting instructions) how the Luminaire shall be mounted. Next to that, the Luminaire manufacturer shall define a setup for measuring the thermal resistance of the Luminaire. This setup should be a good model for the actual application of the Luminaire. Note that this measurement setup can be anything ranging from a free air setup to measurement boxes as defined by, for example UL and IEC for safety tests. It is recommended to use the same test setup for R_{th} measurement as for safety measurement. The ATC will use the setup as defined by the Luminaire manufacturer to measure the thermal resistance of the Luminaire.

6.3 Simplified thermal interface model

6.3.1 General case

See section 6.2.1.

6.3.2 Rated Operating Temperature and safety (informative)

See section 6.2.3.

6.3.3 Thermal overload protection (informative)

See section 6.2.4.

6.3.4 Thermal compatibility check

In order to determine whether a particular LLE or LED Module is thermally compatible with a particular Luminaire, it should be verified that the LLE-Luminaire combination or LED Module-Luminaire combination will operate at $t_r \leq t_{r,}$. The value of $t_{r,}$ is listed in the LLE or LED Module/LED Array Product Data Set. Using the generic thermal model as defined in section 6.2.1, the operating temperature t_r can be determined by:

$$t_r = t_a + R_{th} \cdot P_{th,rear} \qquad \text{EQ. 6-9}$$

The ambient temperature t_a is determined by the application of the LLE-Luminaire combination or LED Module-Luminaire combination. The value of R_{th} is a characteristic of the heat sink. Both t_a and R_{th} should be chosen appropriately by a skilled person.

The value of $P_{th,rear}$ is not listed in the LLE or LED Module/LED Array Product Data Set. However, it can be estimated using the Rated value of P_{th} in the LLE or LED Module/LED Array Product Data Set.

(Informative)
Depending on the required accuracy of the estimation of $P_{th,rear}$, the following methods may be used.

Method 1 – Ignore $P_{th,front}$

In this case $P_{th,rear} = P_{th}$

Method 2 – Estimate $P_{th,front}$ using a thermal simulation.

In this case, $P_{th,rear}$ is calculated using: $P_{th,rear} = P_{th} - P_{th,front}$ and $P_{th,front}$ is estimated using a thermal simulation of the LLE or LED Module in the specific application. This allows the characteristics of the Luminaire also to be taken into account.

6.3.5 Thermal Interface Material

See section 6.2.9.

6.3.6 Surface planarity and roughness

See section 6.2.10. It is recommended that the surface in the Luminaire which serves as a thermal interface has a surface planarity smaller than 0,1 mm and a surface roughness smaller than 3,2 µm.

6.3.7 Aging of LED Light Engine or LED Module/LED Array (informative)

See section 6.2.11.

7 Control interface

This edition Book 1 does not define means to control the light output characteristics of the LED Light Engine or the LED Module/LED Array.