

# PUBLICLY AVAILABLE SPECIFICATION



Zhaga interface specification Book 1 and Book 14

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# PUBLICLY AVAILABLE SPECIFICATION



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Zhaga interface specification Book 1 and Book 14

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COMMISSION

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ZHAGA INTERFACE SPECIFICATION BOOK 1 AND BOOK 14**

## FOREWORD

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Draft PAS	Report on voting
34A/2196/DPAS	34A/2206/RVDPAS

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## INTRODUCTION

This PAS is a reproduction of Zhaga Book 1 Edition 1.8 and Book 14 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 14 Edition 1.2 – Socketable Flat LED Module and LED Light Engine.

Subdivision 2 comprises Zhaga Book 1 Edition 1.8 – Overview and common information, which is essential to the interpretation of Zhaga Book 14 (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.

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## Subdivision 1

### Zhaga Interface Specification Book 14

#### 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 14 defines three socketable LED light engines (with integrated electronic control gears) and three socketable LED modules (without integrated electronic control gears). The intended application is in free air or in a Luminaire that does not introduce a significant temperature increase. Each LED module and LED light engine is identified by a designation.

The LED Modules and the LLEs feature contact caps which fit in corresponding contact holders of the luminaire. The contact caps and contact holders have keys matching specific electrical characteristics of the LED module or the LED light engine. Each key is identified by a designation.

This Book should be read together with Zhaga Book 1.

##### Intended Use

The LED modules and the LED light engines defined in this Book 14 are intended to be installed and replaced by professionals and non-professionals.

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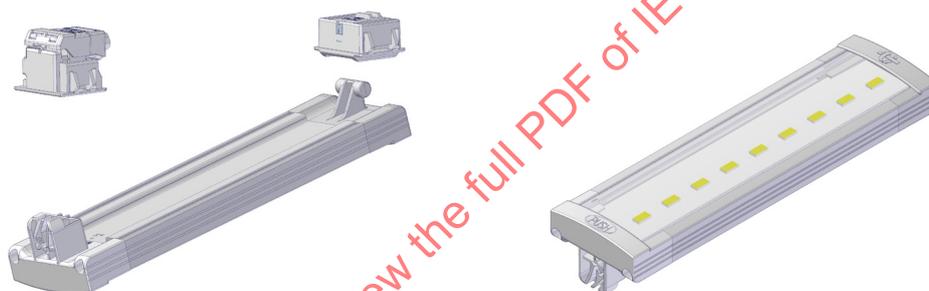
## 1 General

### 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



**Figure 1-1 – 3D-drawings of the Book 14 LED Module or LED Light Engine (informative)**

This Book 14 defines three socketable LED Light Engines (with integrated Electronic Control Gears) and three socketable LED Modules (without integrated Electronic Control Gears). These LED Modules and LLEs have a rectangular shape and are typically applied in general lighting applications. These products are intended to be installed and replaced by professionals and non-professionals.

Figure 1-1 shows informative 3D-drawings of such a LED Module or LLE. The intended application is in free air or in a Luminaire that does not introduce a significant temperature increase. Each LED Module and each LED Light Engine is identified by a designation.

The LED Modules and the LLEs feature contact Caps which fit in corresponding contact Holders of the Luminaire. The contact Caps and contact Holders have keys matching specific electrical characteristics of the LED Module or LED Light Engine. Each key is identified by a designation.

### 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 that 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
[IEC 60598-1]	Luminaires – Part 1: General requirements and tests
[NEMA SSL 7A]	Phase Cut Dimming for Solid State Lighting: Basic Compatibility, NEMA SSL 7A-2013
[7004-187]	IEC 60061-1 standard sheet 7004-187
[7005-187]	IEC 60061-2 standard sheet 7005-187
[7005-187A]	IEC 60061-3 standard sheet 7006-187A
[7006-187B]	IEC 60061-3 standard sheet 7006-187B
[7006-187C]	IEC 60061-3 standard sheet 7006-187C
[7006-187D]	IEC 60061-3 standard sheet 7006-187D
[7006-187E]	IEC 60061-3 standard sheet 7006-187E
[7006-187F]	IEC 60061-3 standard sheet 7006-187F
[7006-187G]	IEC 60061-3 standard sheet 7006-187G
[7006-187I]	IEC 60061-3 standard sheet 7006-187I
[7006-187J]	IEC 60061-3 standard sheet 7006-187J
[7006-187K]	IEC 60061-3 standard sheet 7006-187K
[7006-187L]	IEC 60061-3 standard sheet 7006-187L

### 1.4 Definitions

This section defines terms that have a specific meaning in the context of this Book 14. Terms that have a specific meaning across all Zhaga Books are defined in [Book 1].

Book-14 LED Light Engine	LED Light Engine according to the specifications in this book.
Book-14 LED Module	LED Module according to the specifications in this book.
Cap	The part of the LED Light Engine or LED Module which fits in the Holder of the Luminaire. The Cap/Holder combination serves to retain the LED Light Engine or LED Module in the Luminaire. The Cap/Holder combination may also provide electrical connections between LED Light Engine or LED Module and the Luminaire.

**Holder** The part of the Luminaire which fits to the CAP of the LED Light Engine or LED Module. The Cap/Holder combination serves to retain the LED Light Engine or LED Module in the Luminaire. The Cap/Holder combination may also provide electrical connections between LED Light Engine or LED Module and the Luminaire.

## 1.5 Acronyms

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

## 1.6 Symbols

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

## 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 14 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

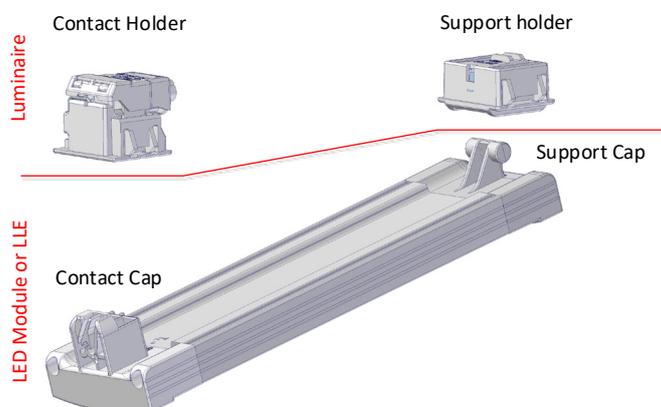
Values that are indicated as typical, as well as values between parentheses, are informative.

## 2 Overview (Informative)

### 2.1 General

General information with respect to the Zhaga Interface Specifications and certification of products that comply with this Book 14 can be found in [Book 1], section 2.

## 2.2 Description of the LED Module and the LED Light Engine



**Figure 2-1 – Schematic overview of the Book 14 LED Module or LLE with Caps and Luminaire with Holders**

A schematic overview of the Book 4 LED Module or LLE with Caps and Luminaire with Holders is depicted in Figure 2-1. This Book 14 defines:

- 3 LED Module/LLE categories with different dimensions and identified by designations,
- Contact Cap, contact Holder, support Cap and support Holder and
- 15 keys for contact Caps and contact Holders, also identified by designations.

In the current Edition 1.2 of the Book 14, 9 keys for contact Caps and Holders are defined while the rest is reserved for future applications. Each LED Module/LLE category can be combined with each key.

## 2.3 Outline of this Book

This Book 14 consists of two parts:

Part 1, Interface Definition, defines the LED Module/LED Light Engine-Luminaire interface in terms of the five sub interfaces:

- The mechanical interface (section 3).
- The photometric interface (section 4).
- The electrical interface (section 5).
- The thermal interface (section 6).
- The control interface (section 7).

Part 2, Compliance Tests, defines:

- Specific tools, which are used for testing compliance of a LED Module, LED Light Engine or a Luminaire (section 8).
- The LED Module/LED Light Engine tests (section 9).
- The Luminaire tests (section 10).

The Annexes to this Book 14 provide the following additional information:

- Requirements on the information that shall be part of the Product Data Sets (Annex A).
- History of changes (Annex B).

**Part 1: Interface Definition**

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### 3 Mechanical interface

#### 3.1 Drawing principles

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

#### 3.2 Overview of the mechanical interface

A Book 14 LED Module or LLE shall have one support Cap as defined in section 3.3.2 and one contact Cap as defined in section 3.3.3.

For each LED Module or LLE to be mounted in a Book 14 Luminaire, the Luminaire shall have one support Holder as defined in section 3.4.2 and one contact Holder as defined in section 3.4.3.

For each of the 3 LED Module/LLE categories Book 14 defines:

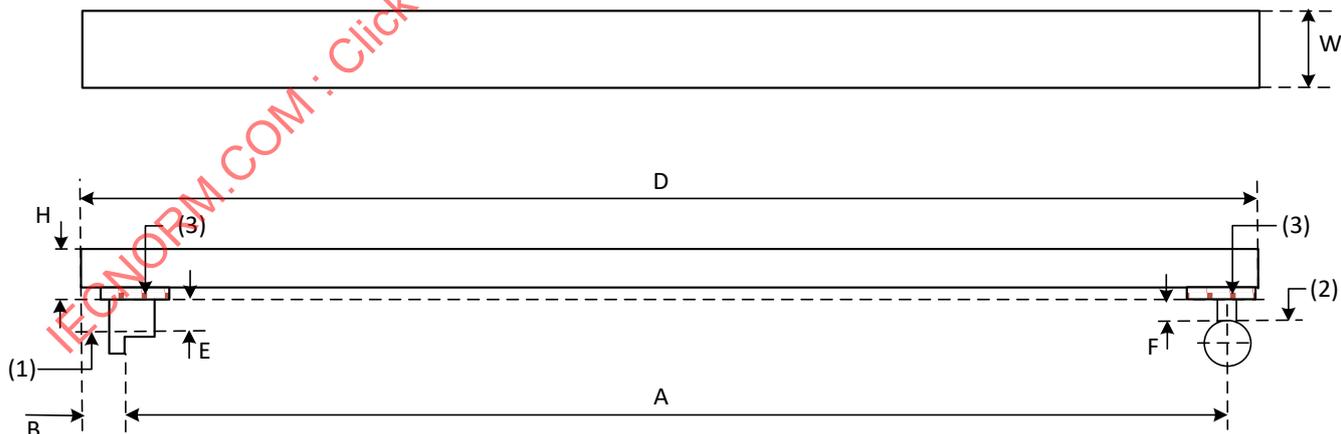
- The maximum outline of the LED Module or LED Light Engine (Section 3.3.1)
- Position of the support Cap and contact Cap in the LED Module and LLE (Section 3.3.1)
- Position of the support Holder and contact Holder in the Luminaire (Section 3.4.1)

#### 3.3 Definition of the mechanical interface of the LED Module and LED Light Engine

For the purpose of this section, the provisions in [Book 1] – section 3.3, apply.

##### 3.3.1 Definition of Book 14 LED Modules or LLEs for different categories

The mechanical dimensions of the Book 14 LED Module or LED Light Engine are defined in Figure 3-1. For each of the LED Module/LLE categories (L60W5, L120W5 and L150W5) the restrictions are listed in Table 3-1.



**Figure 3-1 – Mechanical dimensions of the Book 14 LED Module and LED Light Engines**

Notes to Figure 3-1:

- (1) is the reference plane of the contact Cap. This is the same reference plane as the reference plane (1) in [7004-187].
- (2) is the reference plane support Cap. This is the same reference plane as the reference plane (1) in [7004-187].

- (3) is an optional base of the cap.
- Dimensions E and F delineate the free space for insertion and withdrawal movement.

**Table 3-1 – Values of dimensions for the Book 14 LED Modules and LED Light Engines**

Dimension	LED Module/LLE category designation					
	L60W5		L120W5		L150W5	
	Min.	Max.	Min.	Max.	Min.	Max.
A	553,0	555,0	1152,0	1156,0	1451,5	1456,0
B	--	6,0	--	6,0	--	6,0
D	--	565,0	--	1166,0	--	1466,0
W	--	50	--	50	--	50
H	--	35	--	35	--	35
E	7,3	--	7,3	--	7,3	--
F	3,7	--	3,7	--	3,7	--

### 3.3.2 Definition of the support Cap

The support cap shall comply with all provisions for 'SUPPORT CAP' in [7004-187].

### 3.3.3 Definition of contact Cap

The contact cap shall comply with all provisions for 'SUPPLY CAP' in [7004-187].

### 3.3.4 Mass

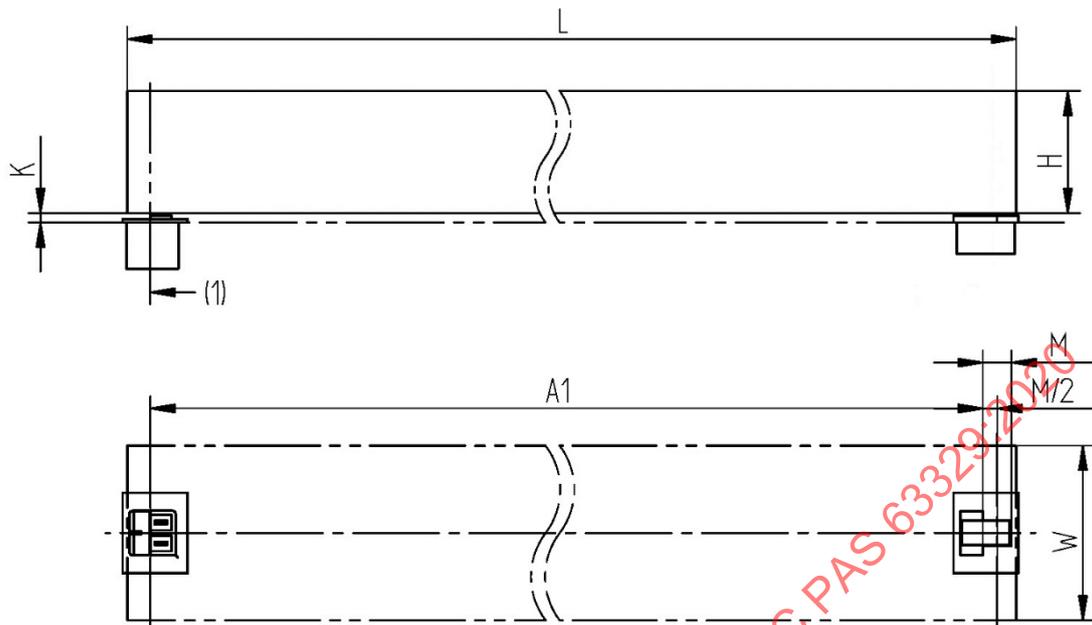
The mass of a Book 14 LED Module or LLE shall be less than or equal to 2,0 kg.

## 3.4 Definition of the mechanical interface of the Luminaire

For the purpose of this section, the provisions in [Book 1] – section 3.3, apply.

### 3.4.1 Definition of Book 14 Luminaires for different categories

For each LLE to be mounted in the Luminaire, the Luminaire shall provide a keep-out zone with dimensions L, W and H. The position of this keep-out zone with respect to the Holders and the distance between the Holders are defined in Figure 3-2. For each of the LLE categories (L60W5, L120W5 and L150W5) the restrictions are listed in Table 3-2.



**Figure 3-2 – Mechanical dimensions of Book 14 luminaires**

Notes to Figure 3-2:

- (1) is the reference plane of the contact Holder.

**Table 3-2 – Values of dimensions for the Book 14 Luminaire**

Dimension	LED Module/LLE category designation					
	L60W5		L120W5		L150W5	
	Min.	Max.	Min.	Max.	Min.	Max.
A1	550	552	1 150	1 152	1 450	1 452
H	35	-	35	-	35	-
K	2,6	-	2,6	-	2,6	-
L	565	-	1 166	-	1 466	-
M	7,6	8,6	7,6	8,6	7,6	8,6
W	50	-	50	-	50	-

### 3.4.2 Definition of the support Holder

The support Holder shall comply with all provisions for ‘SUPPORT HOLDER’ in [7005-187].

### 3.4.3 Definition of contact Holder

The contact Holder shall comply with all provisions for ‘SUPPLY HOLDER’ in [7005-187].

## 4 Photometric interface

### 4.1 Light Emitting Surface

This edition of Book 14 of the Zhaga Interface Specification does not contain requirements on the Light Emitting Surface of the LED Module or the LLE.

## 4.2 Operating conditions

For the purpose of this section, the provisions in [Book 1] – section 4.2 apply, with the following exceptions:

- The requirement on  $t_r$  does not apply.
- The ambient temperature of the LED Module or LLE and test fixture(s) shall be within the range  $25 \pm 1$  °C.

## 4.3 Luminous flux

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

## 4.4 Luminous intensity distribution

This edition of the Book 14 of the Zhaga Interface Specification does not contain requirements on the luminous intensity distribution of the LED Module or the LLE.

## 4.5 Luminance uniformity

This edition of the Book 14 of the Zhaga Interface Specification does not contain requirements on the Luminance uniformity of the LED Module or the LLE.

## 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 the LED Module or the LED Light Engine 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 the LED Module or the LED Light Engine shall be measured under the conditions specified in section 4.2.

# 5 Electrical interface

## 5.1 Electrical interface between LED Module and Luminaire

In case of a Book 14 product being a LED Module or a Luminaire for a LED Module, the requirements in the following sub-sections apply.

### 5.1.1 Nominal input current and forward voltage

The LED Module shall comply with the provisions of [LEDset-Pow].

The LED Module shall have a contact Cap with one of the keys: GR6d-1, GR6d-2, GR6d-3, GR6d-4 or GR6d-5. The LED Module shall meet the requirements on electrical parameters corresponding to the key of the contact Cap as listed in Table 5-1. The polarity of the forward voltage shall be as indicated in [7004-187].

**Table 5-1 – Electrical input characteristics of the LED Module**

Key	Nominal input Current	Forward voltage
GR6d-1	350 mA	$20V \leq V_f \leq 50V$
GR6d-2	500 mA	$20V \leq V_f \leq 50V$
GR6d-3	700 mA	$20V \leq V_f \leq 50V$
GR6d-4	1050 mA	$20V \leq V_f \leq 50V$
GR6d-5	1400 mA	$20V \leq V_f \leq 50V$
GR6d-6	reserved	reserved
GR6d-7	reserved	reserved
GR6d-8	reserved	reserved
GR6d-9	reserved	reserved

The Luminaire shall have a contact Holder with one of the keys: GR6d-1, GR6d-2, GR6d-3, GR6d-4 or GR6d-5. The Luminaire shall meet the requirements on electrical parameters corresponding to the key of the contact Holder as listed in Table 5-2. The polarity of the forward voltage shall be as indicated in [7005-187].

**Table 5-2 – Electrical output characteristics of the Luminaire**

Key	Nominal output Current	Minimum voltage range
GR6d-1	350 mA	20V ... 50V
GR6d-2	500 mA	20V ... 50V
GR6d-3	700 mA	20V ... 50V
GR6d-4	1050 mA	20V ... 50V
GR6d-5	1400 mA	20V ... 50V
GR6d-6	reserved	reserved
GR6d-7	reserved	reserved
GR6d-8	reserved	reserved
GR6d-9	reserved	reserved

### 5.1.2 Electrical insulation

The luminaire Contact Holder shall provide a SELV output as defined in [IEC 60598-1]<sup>1</sup>.

### 5.1.3 Hot plugging

The current edition of this Book 14 does not require any functionality related to 'hot plugging'.

## 5.2 Electrical interface between LLE and Luminaire

In case of a Book 14 product being a LED Light Engine or a Luminaire for a LED Light Engine, the requirements in the following sub-sections apply.

### 5.2.1 Mains power

The LLE shall have a contact Cap with one of the keys: GR6d-10, GR6d-11, GR6d-12 or GR6d-14. The LLE shall meet the requirements on electrical parameters corresponding to the key of the contact Cap as listed in Table 5-3.

<sup>1</sup> In North America a Class 2 output per UL 1310 is determined to meet this requirement.

The Luminaire shall have a contact Holder with one of the keys: GR6d-10, GR6d-11, GR6d-12 or GR6d-14. The Luminaire shall meet the requirements on electrical parameters corresponding to the key of the contact Holder as listed in Table 5-3.

**Table 5-3 – Mains power characteristics of the LLE and the Luminaire**

Key	Input voltage range <sup>2</sup> [V]	Rated frequency [Hz]	Max. Current (A)
GR6d-10	100...127	50 or 60	2
GR6d-11	200...254	50 or 60	2
GR6d-12	250...288	50 or 60	2
GR6d-13	reserved		
GR6d-14	100...288	50 or 60	2
GR6d-15	reserved		

### 5.2.2 Electrical insulation

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

## 6 Thermal interface

Book 14 LED Modules and LLEs are self-cooling and do not have an explicit thermal interface between LED Module/LLE and Luminaire. For this reason, this book does not contain requirements with respect to the thermal interface.

## 7 Control interface

### 7.1 Dimming (optional)

If a LLE supports dimming functionality, such dimming functionality shall comply with the provisions of [NEMA SSL 7A].

<sup>2</sup> This is the input voltage range in which the product shall function as specified.

## Part 2: Compliance Tests

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## **8 Compliance test tools**

### **8.1 LED Module/LED Light Engine test tools**

#### **8.1.1 Gauges for test of mechanical interface**

##### **8.1.1.1 GO gauge for checking the contact Cap**

The GO gauge for checking the contact Cap is defined in [7006-187-1].

##### **8.1.1.2 GO gauge for checking the contact Cap retention path**

The GO gauge for checking the contact Cap retention path is defined in [7006-187A-1].

##### **8.1.1.3 GO and NOTGO gauges for checking the contact position of the contact Cap**

The GO gauge and 'NOGO' gauge for checking the contact position of the contact Cap are defined in [7006-187B].

##### **8.1.1.4 GO and NOTGO gauges for checking the key dimensions of the contact Cap**

The GO and NOTGO gauges for checking the key dimensions of the contact Cap are defined in [7006-187C].

##### **8.1.1.5 GO and NOTGO gauges for checking the key of the contact Cap**

The GO and NOTGO gauges for checking the key of the contact Cap are defined in [7006-187D].

##### **8.1.1.6 GO and NOTGO gauges for checking the support Cap**

The GO and NOTGO gauges for checking the support Cap are defined in [7006-187E].

#### **8.1.2 Test Fixture PETF (photometric and electrical)**

For each LED Module/LLE category, the Test Fixture PETF is an open "Luminaire" with appropriate holders according to the definition in section 3.4.

### **8.2 Luminaire test tools**

#### **8.2.1 Gauges for test of mechanical interface**

##### **8.2.1.1 GO gauge A for checking the contact Holder**

The GO gauge A for checking the contact Holder is defined in [7006-187F].

##### **8.2.1.2 GO gauge B for checking the contact Holder**

The GO gauge B for checking the contact Holder is defined in [7006-187G].

##### **8.2.1.3 NOTGO gauge for checking the contact Holder**

The NOTGO gauge for checking the contact Holder is defined in [7006-187I].

##### **8.2.1.4 GO gauge for checking the key of the contact Holder**

The GO gauges for checking the key of the contact Holder is defined in [7006-187K].

### 8.2.1.5 NOTGO gauges for checking the key of the contact Holder

The NOTGO gauges for checking the key of the contact Holder are defined in [7006-187L].

### 8.2.1.6 GO and NOTGO gauges for checking the support Holder

The GO gauge and NOTGO gauge for checking the support Holder is defined in [7006-187J].

## 9 LED Module/LED Light Engine Compliance Tests

### 9.1 LED Module/LED Light Engine mechanical interface tests

#### 9.1.1 Test of the dimensions D, W, H and A of the LLE

The purpose of this test is to verify the dimensions D, W, H, A and B as defined in Figure 3-1 and Table 3-1.

##### 9.1.1.1 Test equipment

This test should be conducted with a caliper.

##### 9.1.1.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

##### 9.1.1.3 Test procedure and pass criteria

- Determine the designation of the LLE category from the Product Data Set of the LLE under test.
- Find the corresponding restrictions for the dimensions D, W, H, A and B in Table 3-1.
- Measure the dimensions D, W, H, A and B.
- The LLE passes if the measured values of the dimensions D, W, H, A and B are within the restrictions as defined in Table 3-1.

#### 9.1.2 Test of the contact Cap of the LED Module or LLE

The purpose of this test is to verify maximum Cap outline with respect to dimensions A, C, E1, E2, G, H, J and L1 defined in [7004-187] and the combined spacing and displacement of the contacts.

##### 9.1.2.1 Test equipment

This test should be conducted with the gauge as defined in section 8.1.1.1.

##### 9.1.2.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

##### 9.1.2.3 Test procedure and pass criteria

- It shall be possible to insert the Cap into gauge until the Cap is in contact with the gauge surface as defined in [7006-187-1].

#### 9.1.3 Test of the retention path of the contact Cap of the LED Module or LLE

The purpose of this test is to verify the minimum Cap retention path (see [7004-187]) width I and depth K (see [7006-187A]).

#### 9.1.3.1 Test equipment

This test should be conducted with the gauges as defined in section 8.1.1.2.

#### 9.1.3.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

#### 9.1.3.3 Test procedure and pass criteria

- It shall be possible to insert the pin of the gauge into the Cap until the Cap is in contact with the gauge surface X as defined in [7006-187A]. Moreover, it shall be possible to move the pin of the gauge freely in the complete retention path.

#### 9.1.4 Test of the contact position of the contact Cap of the LED Module or LLE

The purpose of this test is to verify the minimum and maximum contact recess.

##### 9.1.4.1 Test equipment

This test should be conducted with the gauges as defined in section 8.1.1.3.

##### 9.1.4.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

##### 9.1.4.3 Test procedure and pass criteria

This procedure shall be conducted for both contacts.

- When inserting the “Go” gauge into the contact cavity it shall be possible that the “GO” indicator touches all 3 edges of the cavity surface as defined in [7006-187B].
- When inserting the “Not Go” gauge into the contact cavity it shall not be possible that the “NOT GO” indicator touches simultaneously all 3 edges of the cavity surface as defined in [7006-187B].

#### 9.1.5 Test of the key dimensions of the contact Cap of the LED Module or LLE

The purpose of this test is to verify minimum and maximum key notch width dimension Y and maximum key height dimension X (see [7006-187C]) of the contact Cap.

##### 9.1.5.1 Test equipment

This test should be conducted with the gauges as defined in section 8.1.1.4.

##### 9.1.5.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

##### 9.1.5.3 Test procedure and pass criteria

- It shall be possible to enter the key notch into the gauge “GO” end until the gauge touches the Cap surface.
- It shall not be possible to insert the gauge “NOT GO” end.

#### 9.1.6 Test of the key of the contact Cap of the LED Module or LLE

The purpose of this test is to verify combined key position and minimum key notch height X (see [7006-187D]) of contact caps.

#### 9.1.6.1 Test equipment

This test should be conducted with the gauges as defined in section 8.1.1.5.

#### 9.1.6.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

#### 9.1.6.3 Test procedure and pass criteria

- It shall be possible to stick the gauge with the relevant key designation over the Cap cavity wall containing the key notches until surface X of the gauge is fully in contact with the Cap cavity wall. In this position the key notches shall be co-planar with or project beyond the gauge surface.
- Additionally, when the gauge is fully inserted until it is in contact with the top of the cavity there shall be no gap between the top of the key notch and the gauge slot end.
- It shall not be possible to insert any of the gauges with a non-similar key designation over the Cap cavity wall.

#### 9.1.7 Test of the support Cap of the LED Module or LLE

The purpose of this test is to verify maximum support Cap outline and free space with respect to dimensions A, B, C, K and W and the maximum position from the Cap end T2 (see [7006-187E]).

##### 9.1.7.1 Test equipment

This test should be conducted with the gauges as defined in section 8.1.1.6.

##### 9.1.7.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

##### 9.1.7.3 Test procedure and pass criteria

- It shall be possible to fully insert the Cap into gauge 1 “GO” side from the outer Cap end. In this position the surface X of the gauge shall be co-planar with or project beyond the outer LED Module/LLE surface.
- Gauge 1 is then applied in turn with the “NOT GO” side. In this position it shall not be possible to fully insert the Cap.
- Additionally, it shall not be possible to fully insert the Cap into gauge 2.

#### 9.2 LED Module/LED Light Engine photometric interface tests

##### 9.2.1 Test on luminous flux

For the purpose of this section, the provisions in [Book 1] – section A.0.2.1 (for LED Module) or section A.1.2.1 (for LLE) apply. The Test Fixture PETF is defined in section 8.1.2.

##### 9.2.2 Test on correlated color temperature (CCT)

For the purpose of this section, the provisions in [Book 1] – section A.0.2.3 (for LED Module) or section A.1.2.3 (for LLE) apply. The Test Fixture PETF is defined in section 8.1.2.

##### 9.2.3 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 (for LED Module) or section A.1.2.4 (for LLE) apply. The Test Fixture PETF is defined in section 8.1.2.

### 9.3 LED Light Engine Electrical interface tests

In case of a Book 14 product being a LED Light Engine, no the compliance tests on the electrical interface need to be performed. *Note that the electrical interface is implicitly tested by performing the photometric tests as defined in section 9.2.*

### 9.4 LED Module Electrical interface tests

In case of a Book 14 product being a LED Module, the compliance test in this section shall be performed. *Note that the input current is implicitly tested by performing the photometric tests as defined in section 9.2.*

#### 9.4.1.1 Test equipment

- Adjustable current source and voltage meter.

#### 9.4.1.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

#### 9.4.1.3 Test procedure and pass criteria

- Check the key of the Cap of the LED Module under test and find the corresponding input current and forward voltage range in Table 5-1.
- Apply the nominal current corresponding to the key to the LED Module under test and measure the forward voltage.
- Check whether the measured forward voltage is within the range as specified in Table 5-1.

### 9.5 LED Module/LED Light Engine thermal interface tests

This edition of Book 14 of the Zhaga Interface Specification does not contain compliance tests for the Thermal interface of the LED Module or the LLE.

### 9.6 LED Light Engine control interface tests

#### 9.6.1 Test of dimming functionality

The purpose of this test is to verify the dimming functionality of the LLE under test. This test applies only to LLEs and only if the data sheet of the LLE under test indicates that dimming functionality is supported.

#### 9.6.1.1 Test equipment

See [NEMA SSL 7A] Section 4.

#### 9.6.1.2 Test conditions

See [NEMA SSL 7A] Section 4.

#### 9.6.1.3 Test procedure

See [NEMA SSL 7A] Section 4.

#### 9.6.1.4 Test procedure

The Socketable LLE under test passes if all tests defined in [NEMA SSL 7A] Section 4 pass.

### 9.7 LED Module/LED Light Engine Product Data Set test

For the purpose of this section, the provisions in [Book 1] – section A.0.5 (for LED Module) or section A.1.6 (For LLE) apply.

## 10 Luminaire compliance tests

### 10.1 Luminaire mechanical interface tests

#### 10.1.1 Test of the dimensions L, W, H and A1 of the Luminaire

The purpose of this test is to verify the dimensions L, W, H, M and A1 as defined in defined in Figure 3-2 and Table 3-2.

##### 10.1.1.1 Test equipment

This test should be conducted with a caliper.

##### 10.1.1.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

##### 10.1.1.3 Test procedure and pass criteria

This test shall be performed for each LLE position in the Luminaire.

- Determine the designation of the LLE category from the Product Data Set of the Luminaire under test.
- Find the corresponding restrictions for the dimensions L, W, H, M and A1 in Table 3-2.
- Measure the dimensions L, W, H, M and A1.
- The Luminaire passes if the measured values of the dimensions L, W, H, M and A1 are within the restrictions as defined in Table 3-2.

#### 10.1.2 Test of the contact Holder of the Luminaire – part 1

The purpose of this test is to verify contact Holders for a proper acceptance of maximum caps at maximum pin distance in the following respects:

- height and width A, C, G, H, L, O, and T1 (See [7006-187F])
- free space and position for retention system I, K and S1 (See [7006-187F])

##### 10.1.2.1 Test equipment

This test should be conducted with the gauge as defined in section 8.2.1.1.

##### 10.1.2.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

##### 10.1.2.3 Test procedure and pass criteria

- It shall be possible to insert the gauge into the contact Holder until the gauge is in contact with the surface of the contact Holder.

#### 10.1.3 Test of the contact Holder of the Luminaire – part 2

The purpose of this test is to verify contact Holders for a proper acceptance of maximum caps at minimum pin distance in the following respects:

- height and width A, C, G, H, L, O, and T1 (See [7006-187G])
- free space and position for retention system I, K and S1 (See [7006-187G])

##### 10.1.3.1 Test equipment

This test should be conducted with the gauge as defined in section 8.2.1.2.

### 10.1.3.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

### 10.1.3.3 Test procedure and pass criteria

- It shall be possible to insert the gauge into the contact Holder until the gauge is in contact with the surface of the contact Holder.

### 10.1.4 Test of the contact Holder of the Luminaire – part 3

The purpose of this test is to verify contact Holders for maximum inner cavity width and length A and L (See [7006-187I]).

#### 10.1.4.1 Test equipment

This test should be conducted with the gauge as defined in section 8.2.1.3.

#### 10.1.4.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

#### 10.1.4.3 Test procedure and pass criteria

- It shall not be possible to insert the gauge into the contact Holder up to the marking.

### 10.1.5 Test of the key of the contact Holder of the Luminaire – part 1

The purpose of this test is to verify contact Holders key position and minimum key slot dimensions X and Y (See [7006-187K]).

#### 10.1.5.1 Test equipment

This test should be conducted with the gauges as defined in section 8.2.1.4.

#### 10.1.5.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

#### 10.1.5.3 Test procedure and pass criteria

- It shall be possible to insert the relevant key gauge into the contact Holder up to the marking as indicated in [7006-187K].
- It shall not be possible to insert any of the gauges with a non-similar key designation into the key slots.

### 10.1.6 Test of the key of the contact Holder of the Luminaire – part 2

The purpose of this test is to verify contact Holder's maximum key slot dimension Y (See [7006-187L]).

#### 10.1.6.1 Test equipment

This test should be conducted with the gauge as defined in section 8.2.1.5.

#### 10.1.6.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

#### 10.1.6.3 Test procedure and pass criteria

- It shall not be possible to insert the relevant key gauge into the key slots.

### 10.1.7 Test of support Holder of the Luminaire

The purpose of this test is to verify the support Holder for a proper acceptance of maximum support caps and to check maximum dimension B. (See [7006-187J]).

#### 10.1.7.1 Test equipment

This test should be conducted with the gauges as defined in section 8.2.1.6.

#### 10.1.7.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

#### 10.1.7.3 Test procedure and pass criteria

- It shall be possible to fully insert the “GO” gauge into the support Holder retention slot.
- It shall not be possible to enter the retention slot with the “NOTGO” gauge.

### 10.2 Luminaire for LED Light Engine Electrical interface tests

In case of a Book 14 product being a Luminaire for LED Light Engine(s), no the compliance tests on the electrical interface need to be performed.

### 10.3 Luminaire for LED Module Electrical interface tests

In case of a Book 14 product being a Luminaire for a LED Module(s), the compliance test in this section shall be performed for each LED Module position in the Luminaire.

#### 10.3.1.1 Test equipment

- Test Circuit as defined in Annex A of [LEDset-Pow].

#### 10.3.1.2 Test conditions

This test shall be conducted at  $25 \pm 5$  °C.

#### 10.3.1.3 Test procedure and pass criteria

- Check the key of the Holder of the Luminaire under test and find the corresponding output current and forward voltage range in Table 5-1. Operating point C is defined as [nominal current,  $V_{f,max}$ ] and point D is defined as [nominal current,  $V_{f,min}$ ].
- The following steps shall be executed for both operating points C and D:
  - 1) Set resistance R1 in the test circuit to the minimum differential resistance  $R_{diff,min}$  as specified in Annex B of [LEDset-Pow], with  $I_{out}$  and  $V_f$  corresponding to the current and voltage of the operating point.
  - 2) Use voltage source U1 of the test circuit to drive the output voltage  $U_{out}$  of the Luminaire under test, measured across its LED+ and LED– terminals, to the forward voltage at the operating point.
  - 3) Verify that the Luminaire under test operates as intended for at least 10 seconds without shutting down or malfunctioning otherwise. *An example of malfunctioning is a flickering behavior of the Luminaire output current.*
  - 4) Repeat steps 1 to 3, setting resistance R1 to the maximum differential resistance  $R_{diff,max}$  as specified in Annex B of [LEDset-Pow] for  $I_{out}$  and  $V_f$  according to the current at the operating point.

### 10.4 Luminaire Product Data Set test

For the purpose of this section, the provisions in [Book 1] – section A.2.6 apply.

**Annexes**

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## 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 14 are listed.

#### LED Module/LED Light Engine Product Data Set

The LED Module/LED Light Engine Product Data Sets shall contain the following information:

- Book 14 LED Module/LLE category designation.
- Key of contact Cap.
- The luminous flux category at  $t_{amb} = 25^{\circ}C$ .
- The CCT and CRI category at  $t_{amb} = 25^{\circ}C$  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.

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

#### Luminaire Product Data Set

The Luminaire Product Data Sets shall contain the following information:

- Book 14 LED Module/LLE category designation
- Key of contact Holder

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**Annex B****History of Changes****Table B-1 – Changes from Edition 1.1 to Edition 1.2.**

<b>Location</b>	<b>Change</b>
Complete document	Mechanical specification of caps and holders by reference to IEC standard sheets instead of explicit specification in this document
Complete document	Editorial updates

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## 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.

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## 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
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### 1.4 Common definitions<sup>3</sup>

Ambient Temperature	Average temperature of the air in the environment where the Luminaire (or Test Fixture) is applied. A few typical examples are: <ul style="list-style-type: none"> <li>• 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.</li> <li>• 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.</li> </ul>
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 establishes electrical contact with the LED Light Engine, LED Module or LED Array.

<sup>3</sup> The definitions are possibly further restricted in the other Zhaga Books.

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 light output 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.

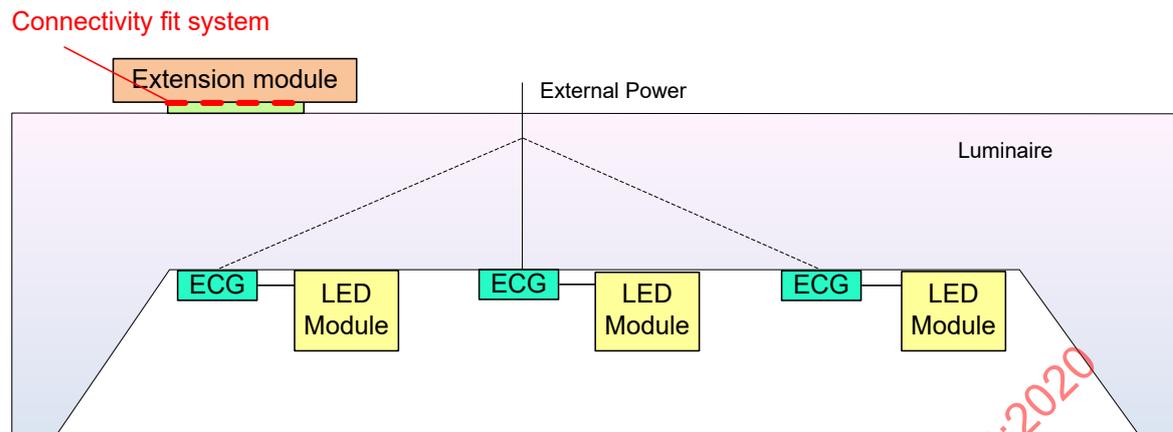
The Zhaga interface specifications do not define safety requirements (electrical, thermal etcetera) of Zhaga products. There may be a recommendation to specify in the Product Data Set of the LLE, LED Module or LED Array the implemented electrical insulation.

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.

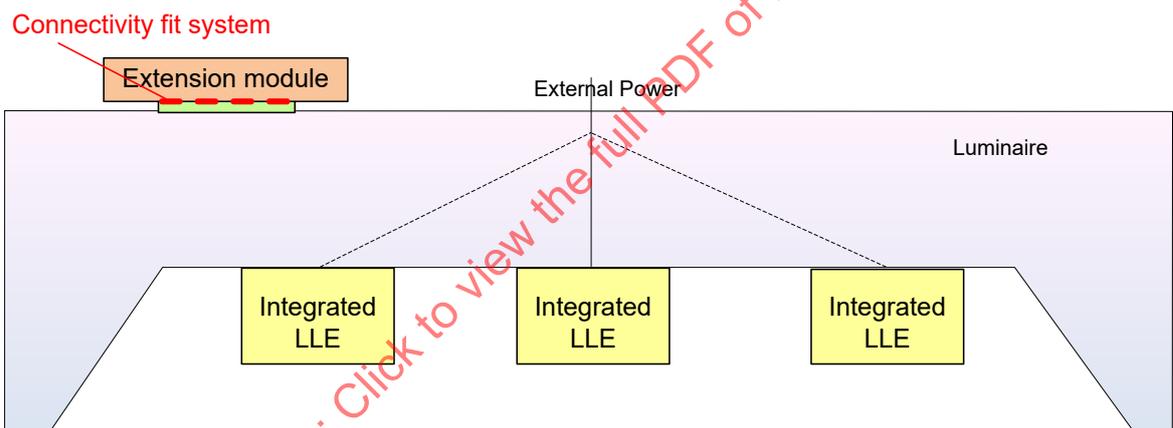
### 2.2 Zhaga building blocks and interfaces

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**



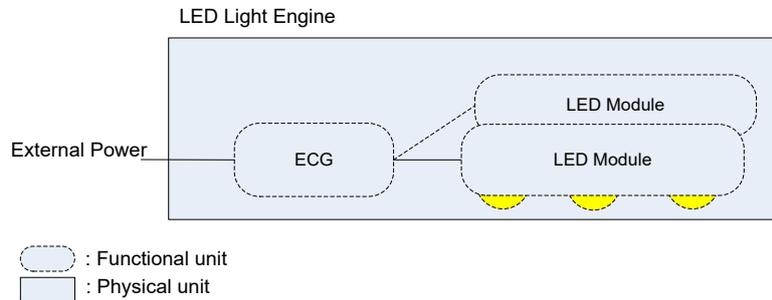
**Figure 2-2 – Schematic overview of a Luminaire and one or more integrated LED Light Engines**

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.

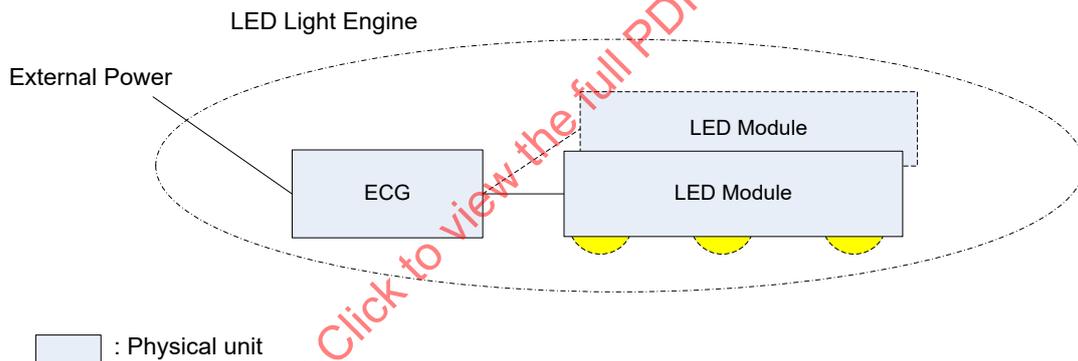
The Electronic Control Gear is defined as a unit that is located between the External Power and one or more LED Modules to provide the LED Module(s) with an appropriate voltage or current. It may consist of one or more separate components, and may include additional functionality, such as means for dimming,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

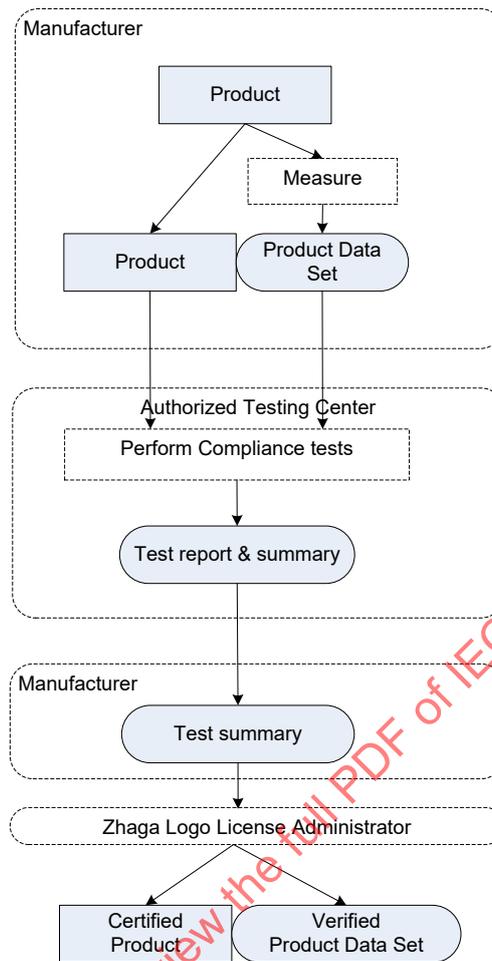


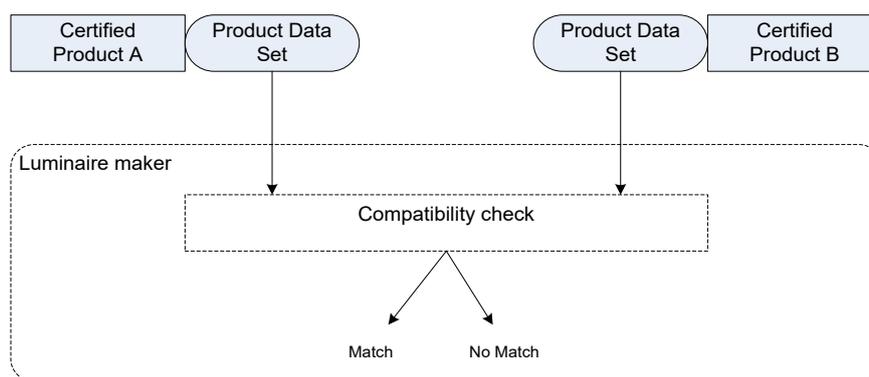
Figure 2-5 – Overview of test and certification of Zhaga products

### 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  $25 \pm 5$  °C. 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.

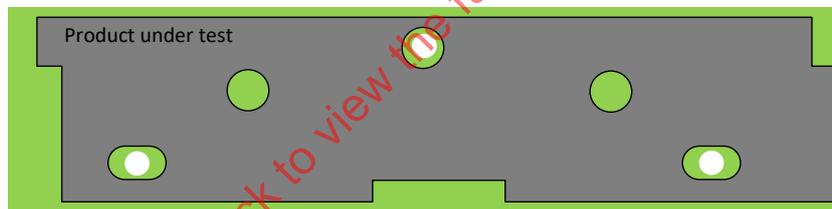


**Figure 3-1 – Example of a Demarcation Model (2-dimensional)**

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.

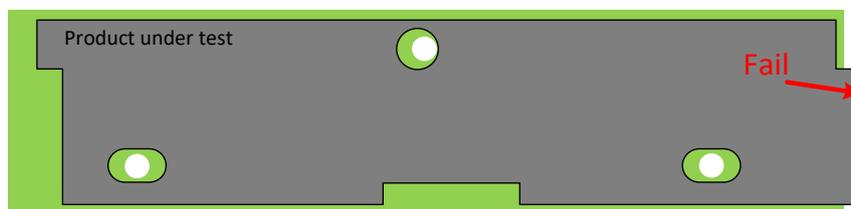
Figure 3-1 shows a Demarcation model. For simplicity, this is a 2-dimensional model rather than a 3-dimensional model but the principle is exactly the same. The green area is the keep-in zone for the product and the keep-out zone for the product's environment. It shows that the product can have any shape 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.

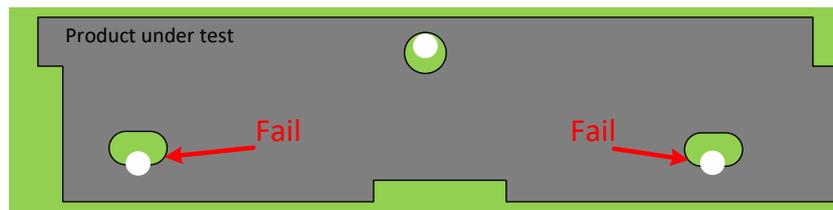


**Figure 3-2 – Example of a product which is compliant with the Demarcation Model**

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 <sup>4</sup>	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  $25 \pm 1$  °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.

<sup>4</sup> 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  $25 \pm 1$  °C.
- The heat sink(s) of the test fixture(s) shall maintain the temperature  $t_r$  or  $t_p$  within the range  $t_{r, rated} \pm 1$  °C or  $t_{p, rated} \pm 1$  °C 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.

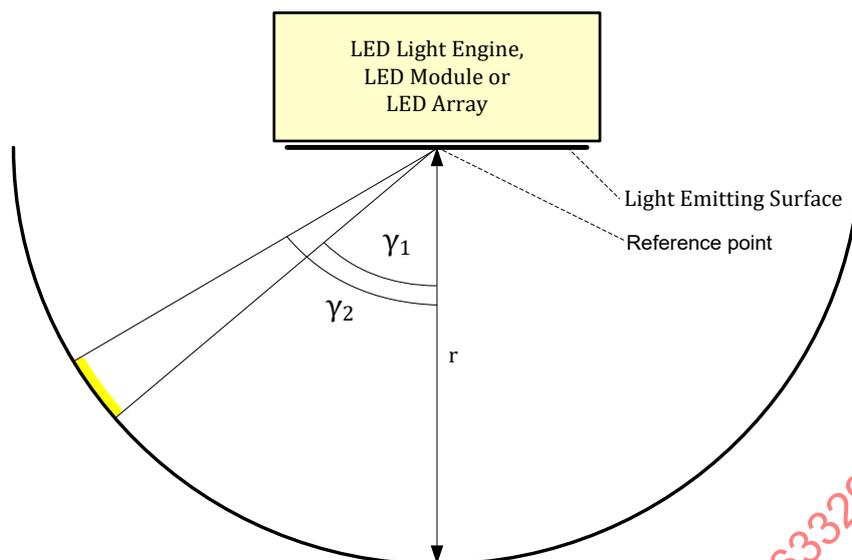
**Table 4-3 – Definition of luminous flux categories**

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  $\gamma_1$  and  $\gamma_2$ , as shown in Figure 4-1.



**Figure 4-1 – Rotationally symmetric solid angle bounded by the polar angles  $\gamma_1$  and  $\gamma_2$  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 faceted 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.

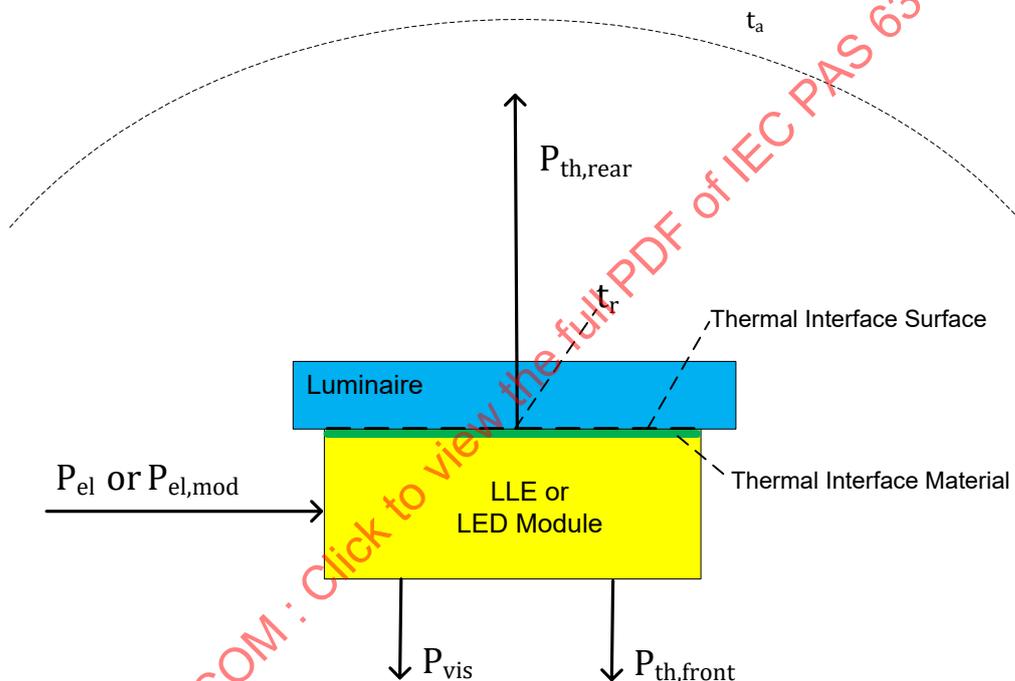
In section 6.2, the generic thermal interface model is defined whereas a simplified model is defined in section 6.3. The simplified model is applicable when a Luminaire maker applies a LLE or LED Module in a Luminaire.

## 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**

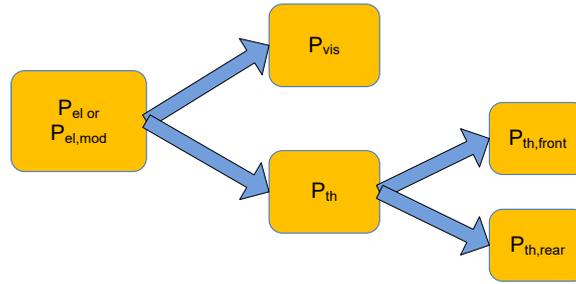
Figure 6-1 illustrates the model of the thermal interface between the LLE or LED Module and the Luminaire. The LLE or LED Module consumes an amount of electrical power  $P_{el}$  and  $P_{el,mod}$  respectively. This power is converted into visible light and heat:

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

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

Here,  $P_{vis}$  is defined as the radiant flux in the visible light spectrum ( $380 \text{ nm} < \lambda < 780 \text{ nm}$ )<sup>5</sup>.

<sup>5</sup> IR radiation is not included in  $P_{vis}$  and it is assumed that radiation in the range  $\lambda < 380 \text{ nm}$  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  $P_{th,front}$ <sup>6</sup>. Typically a substantial part of the thermal power will be drained through the Thermal Interface Surface to the heat sink of the Luminaire<sup>7</sup>. This portion is denoted by  $P_{th,rear}$ .

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

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<sup>8</sup>. 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 ( $t_{r,max}$ ) and the value of  $t_{r,max}$  shall be such that if  $t_r = t_{r,max}$ , 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 ( $P_{th,rear}$ ). Using a simple 1-dimensional model, the following relation is obtained:

$$t_r = t_a + R_{th} \cdot P_{th,rear} \tag{EQ. 6-4}$$

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

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

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

<sup>6</sup>  $P_{th,front}$  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.

<sup>7</sup> Heat transfer via conduction through other parts of the system is assumed to be negligible.

<sup>8</sup> "steady state" is defined in section A.1.3.5.

### 6.2.2 Test Fixture TPTF

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

### 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 ( $R_{th,max}$ ) depends on the Ambient Temperature. With increasing Ambient Temperature  $R_{th,max}$  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  $R_{th,max}$  for several values of the Ambient Temperature. For each type of LLE or LED Module, Product Data Set requirements with respect to  $R_{th,max}$  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  $R_{th,max}$  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  $R_{th,max}$  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<sup>9</sup>. For such systems, the thermal resistance of the Luminaire is defined as:

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

with  $t_{r,i}$  : temperature  $t_r$  of a LLE<sub>i</sub> or LED Module<sub>i</sub>

$P_{th,rear}$  : 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 ( $P_{th,rear}$ ). For that reason several values of  $P_{th,rear}$  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<sup>10</sup> 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  $R_{th,max}$  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  $R_{th,max}$  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:*

<sup>9</sup> 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.

<sup>10</sup> "thermally compatible" means that the LLE-Luminaire or LED Module/LED Array-Luminaire combination will operate at  $t_r \leq t_{r,max}$ .

<b>Data sheet of LLE #1</b>					<b>Data sheet of LLE #2</b>				
$t_{r,max}$ (°C)	65				$t_{r,max}$ (°C)	80			
$P_{th,rear}$ (W)	18				$P_{th,rear}$ (W)	35			
$t_a$ (°C)		30	40	50	$t_a$ (°C)		30	40	50
$R_{th,max}$ (K/W)		1.9	1.4	0.8	$R_{th,max}$ (K/W)		1.4	1.1	0.9
<b>Data sheet of Luminaire #1</b>					<b>Data sheet of Luminaire #2</b>				
Max. $t_a$ (°C)		30			Max. $t_a$ (°C)		40		
$R_{th}$ at $P_{th,rear} = 10$ W (K/W)		1.8			$R_{th}$ at $P_{th,rear} = 10$ W (K/W)		0.9		
$R_{th}$ at $P_{th,rear} = 20$ W (K/W)		1.6			$R_{th}$ at $P_{th,rear} = 20$ W (K/W)		0.8		
$R_{th}$ at $P_{th,rear} = 30$ W (K/W)		1.5			$R_{th}$ at $P_{th,rear} = 30$ W (K/W)		0.7		
$R_{th}$ at $P_{th,rear} = 40$ W (K/W)		1.4			$R_{th}$ 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:

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

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.

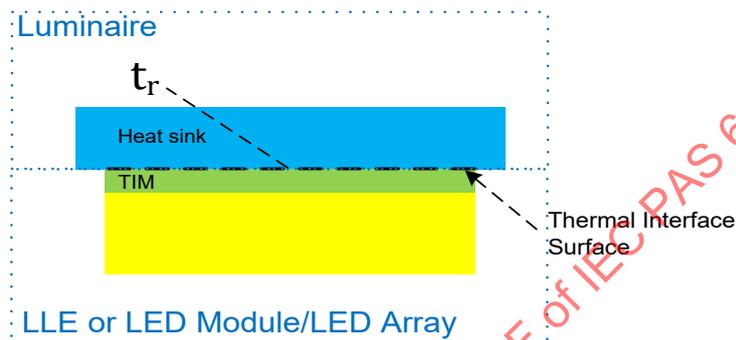
The parameter  $R_{sp}^{max}$  is defined as the maximum value of all spreading resistance values:

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

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:

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

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  $\mu\text{m}$ .

**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.

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## Annex A

### Compliance tests

#### A.0 LED Module/LED Array compliance tests

The compliance tests defined in this section A.0 are applicable if the device-under-test is a LED Module or a LED Array.

##### A.0.1 LED Module/LED Array mechanical interface test

###### A.0.1.1 Test in the mechanical interface or the LED Module/LED Array

The purpose of this test is to verify the dimensions of the mechanical interface of the LED-Module/LED Array-under-test.

###### A.0.1.1.1 Test equipment

The mechanical dimensions may be tested with (semi-)automated 3D measuring equipment like a non-contact optical measuring system. Measurement accuracy of  $\pm 0,01$  mm shall be achieved.

###### A.0.1.1.2 Test conditions

All mechanical dimensions shall be verified at an Ambient Temperature in the range  $25 \pm 5$  °C.

###### A.0.1.1.3 Test procedure

Measure all relevant dimensions of the mechanical interface of the LED-Module/LED Array-under-test. This may involve a measurement of the Demarcation model. See Annex B for guidelines on Demarcation measurement.

###### A.0.1.1.4 Pass criteria

The LED-Module/LED Array-under-test passes if all requirements with respect to the mechanical dimensions as defined in the appropriate Book are met.

##### A.0.2 LED Module/LED Array photometric interface tests

###### A.0.2.1 Test on Luminous Flux

The purpose of this test is to verify the Rated luminous flux category of the LED-Module/LED Array-under-test.

###### A.0.2.1.1 Test equipment

- Test Fixture PETF. For each type of LED Module/LED Array, the Test Fixture PETF is defined in the respective Book.
- A photometric measurement system as defined in [IES LM-79-08], section 9.1.

###### A.0.2.1.2 Test conditions

The test conditions for the LED-Module/LED Array-under-test shall be according to the operating conditions as defined in the respective Book.

**A.0.2.1.3 Test procedure**

- Attach the LED-Module/LED Array-under-test to the Test Fixture PETF using torque, Thermal Interface Material and the fixation means as specified by the manufacturer.
- Connect the Test Fixture PETF to the photometric measurement system.
- Connect the LED Module/LED Array to a power source and turn on the power.
- Adjust the Ambient Temperature and the temperature  $t_r$  such that, after stabilization (see section A.1.3.5), all test conditions are met.
- Perform the test as described in [IES LM-79-08], section 9.1.

**A.0.2.1.4 Pass criteria**

The LED-Module/LED Array-under-test passes if the measured luminous flux value complies with the Rated luminous flux category as defined in the respective Book, extended with 5 % on either side.

*Example: if the Rated luminous flux category is defined from 500 to 1000 lm, the LED Module/LED Array passes if the measured value is in the range from 475 to 1050 lm. The LED Module/LED Array fails if the measured value is less than 475 lm or more than 1050 lm.*

**A.0.2.2 Test on Relative Partial Luminous Flux and beam angle**

The purpose of this test is to verify Relative Partial Luminous Flux and/or Rated beam angle of the LED-Module/LED Array-under-test.

**A.0.2.2.1 Test equipment**

- Test Fixture PETF. For each type of LED Module/LED Array, the Test Fixture PETF is defined in the respective Book.
- A goniophotometer as defined in [IES LM-79-08], section 9.3.

**A.0.2.2.2 Test conditions**

The test conditions for the LED-Module/LED Array-under-test shall be according to the operating conditions as defined in the respective Book.

**A.0.2.2.3 Test procedure**

- Attach the LED-Module/LED Array-under-test to the Test Fixture PETF using torque, Thermal Interface Material and the fixation means as specified by the manufacturer.
- Connect the Test Fixture PETF in the photometric center of the goniophotometer.
- Connect the LED Module/LED Array to a power source and turn on the power.
- Adjust the Ambient Temperature and the temperature  $t_r$  such that, after stabilization (see section A.1.3.5), all test conditions are met.
- Perform the test as described in [IES LM-79-08], section 9.3.
- Calculate the Relative Partial Luminous Flux according to [CIE 52].
- Calculate the beam angle according to [IEC TR 61341:2010].

**A.0.2.2.4 Pass criteria**

The LED-Module/LED Array-under-test passes if for all CIE cumulative flux zones holds that the measured Relative Partial Luminous Flux values comply with the Relative Partial Luminous Flux zone as defined in the respective Book, extended with 5 % on either side.

*Example: if the CIE cumulative flux zone is defined by Relative Partial Luminous Flux from 40 % to 50 %, the LED Module/LED Array passes if the measured value is in the range from 38 % to 52,5 %. The LED Module/LED Array fails if the measured value is less than 38 % or more than 52,5 %.*

The LED-Module/LED Array-under-test passes if the measured beam angle complies with the Rated beam angle category as defined in section 4.4. For the comparison, the boundaries of the beam angle category shall be extended with 5 % on either side.

*Example: if the Rated beam angle category is defined from 40° to 80°, the LED Module/LED Array passes if the measured value is in the range from 38° to 84°. The LED Module/LED Array fails if the measured value is less than 38° or more than 84°.*

### **A.0.2.3 Test on correlated color temperature (CCT)**

The purpose of this test is to verify the Rated CCT category of the LED-Module/LED Array-under-test.

#### **A.0.2.3.1 Test equipment**

- Test Fixture PETF. For each type of LED Module/LED Array, the Test Fixture PETF is defined in the respective Book.
- A sphere-spectroradiometer system as defined in [IES LM-79-08], section 9.1.

#### **A.0.2.3.2 Test conditions**

The test conditions for the LED-Module/LED Array-under-test shall be according to the operating conditions as defined in the respective Book.

#### **A.0.2.3.3 Test procedure**

- Attach the LED-Module/LED Array-under-test to the Test Fixture PETF using torque, Thermal Interface Material and the fixation means as specified by the manufacturer.
- Connect the Test Fixture PETF tightly to the opening of the integrating sphere.
- Connect the LED Module to a power source and turn on the power.
- Adjust the Ambient Temperature and the temperature  $t_r$  such that, after stabilization (see section A.1.3.5), all test conditions are met.
- Perform the test as described in [IES LM-79-08], section 9.1.
- Calculate CCT according to [ANSI C78.377].

#### **A.0.2.3.4 Pass criteria**

The LED-Module/LED Array-under-test passes if the calculated CCT is within the quadrangle that is associated with the Rated CCT category, extended with 0.002 in each direction.

*Example: if the quadrangle that is associated with the Rated CCT category is defined by the coordinates (0,5/0,5), (0,6/0,5), (0,5/0,6) and (0,6/0,6), then LED Module/LED Array passes if the measured value is in the quadrangle defined by the coordinates (0,5-0.002/0,5-0.002), (0,6+0.002/0,5-0.002), (0,5-0.002/0,6+0.002) and (0,6+0.002/0,6+0.002). The LED Module/LED Array fails if the measured value is outside the quadrangle defined by the coordinates (0,5-0.002/0,5-0.002), (0,6+0.002/0,5-0.002), (0,5-0.002/0,6+0.002) and (0,6+0.002/0,6+0.002).*

### **A.0.2.4 Test on color rendering index**

The purpose of this test is to verify the Rated CRI of the LED-Module/LED Array-under-test.

#### **A.0.2.4.1 Test equipment**

- Test Fixture PETF. For each type of LED Module/LED Array, the Test Fixture PETF is defined in the respective Book.
- A sphere-spectroradiometer system as defined in [IES LM-79-08], section 9.1.