

# PUBLICLY AVAILABLE SPECIFICATION



**Zhaga Interface Specification Book 20 including Book 1 – Smart interface  
between indoor luminaires and sensing/communication modules**

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INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 29.140.99

ISBN 978-2-8322-1093-3

**Warning! Make sure that you obtained this publication from an authorized distributor.**

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

# ZHAGA INTERFACE SPECIFICATION BOOK 20 INCLUDING BOOK 1 – SMART INTERFACE BETWEEN INDOOR LUMINAIRES AND SENSING/COMMUNICATION MODULES

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This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document

| Draft PAS   | Report on voting |
|-------------|------------------|
| 34/891/DPAS | 34/901/RVDPAS    |

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## INTRODUCTION

This PAS is a reproduction of Zhaga Book 1 Edition 1.9 and Book 20 Edition 1.0 with no change introduced.

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

Section 1 comprises Zhaga Book 20 Edition 1.0 – Smart interface between indoor luminaires and sensing/communication modules.

Section 2 comprises Zhaga Book 1 Edition 1.9 – Overview and common information.

Zhaga Book 1 is essential to the interpretation of Zhaga Book 20 (and other Zhaga books).

The intention is for the content of this PAS to be incorporated within one or more International Standards following the IEC Directives and drafting rules.

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## Section 1:

### Zhaga Interface Specification Book 20

#### Summary (informative)

##### Background

Zhaga is a global association of lighting companies that is standardizing interfaces of components of LED luminaires, including LED light engines, LED modules, LED arrays, holders, electronic control gears (LED drivers), sensors, communication modules and connectivity fit systems. This helps to streamline the LED lighting supply chain, and to simplify LED luminaire design and manufacturing. Zhaga continues to develop specifications based on the inter-related themes of interoperable components, smart and connected lighting, and serviceable luminaires.

##### Contents

Book 20 defines a smart interface between an indoor LED luminaire and a sensing/communication module. The module connects to the LED driver and control system, and typically can provide sensory inputs or enable communication between network components. Modules can be installed and replaced in the field.

Key benefits are provided for

- luminaire makers, as certified sensors from multiple suppliers are available with a range of different functions
- installers, as certification on interoperability of components exists
- end-users, as the luminaire can be adapted with modules for different functions, like air quality, presence detection, light levels etc.

This Book should be read together with Zhaga Book 1.

##### Intended Use

The luminaire extension module defined in this Book 20 is intended to be installed and replaced by professionals and non-professionals.

## **1 General**

### **1.1 Introduction**

Zhaga is a global association of lighting companies that is standardizing interfaces of components of LED luminaires, including LED light engines, LED modules, LED arrays, holders, electronic control gears (LED drivers), sensors, communication modules and connectivity fit systems. This helps to streamline the LED lighting supply chain, and to simplify LED luminaire design and manufacturing. Zhaga continues to develop specifications, called books, based on the inter-related themes of interoperable components, smart and connected lighting, and serviceable luminaires.

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**

Book 20 defines a smart interface between an indoor LED luminaire and a sensing/communication module. The module connects to the LED driver and control system, and typically can provide sensory inputs or enable communication between network components. Modules can be installed and replaced in the field.

### **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 ISO/IEC Directives, Part 2. 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.                                                                   |
| [DALI – Part 101]  | IEC 62386-101:2014, Digital addressable lighting interface – Part 101: General requirements – System components, Edition 2.0, 2014-11.    |
| [DALI – Part 102]  | IEC 62386-102:2014, Digital addressable lighting interface – Part 102: General requirements – Control gear, Edition 2.0, 2014-11.         |
| [DALI – Part 103]  | IEC 62386-103:2014, Digital addressable lighting interface – Part 103: General requirements – Control devices, Edition 2.0, 2014-11.      |
| [DALI – Part 207]  | IEC 62386-207, Digital addressable lighting interface – Part 207: Particular requirements for control gear – LED modules (device type 6). |
| [DALI – Part 250]  | DiiA specification – DALI Part 250 – Integrated Bus Power Supply, Device Type 49, Version 1.1, October 2019.                              |
| [DALI – Part 251]  | DiiA specification – DALI Part 251 – Memory bank 1 extension, Device Type 50, Version 1.1, October 2019.                                  |
| [DALI – Part 252]  | DiiA specification – DALI Part 252 – Energy reporting, Device Type 51, Version 1.1, October 2019.                                         |
| [DALI – Part 253]  | DiiA specification – DALI Part 253 – Diagnostics & Maintenance, Device Type 52, Version 1.1, October 2019.                                |
| [DALI – Part 351]  | DiiA specification – DALI Part 351 – Luminaire-mounted Control Devices, Version 1.0, October 2019.                                        |
| [D4i Requirements] | DiiA Requirements – D4i Certification and Trademark use, Version 1.0, October 2019.                                                       |
| [DiiA Database]    | <a href="https://www.digitalilluminationinterface.org/products">https://www.digitalilluminationinterface.org/products</a>                 |
| [LoC-Luminaire]    | Template for letter of confirmation for Book-20 Luminaires, published on the Zhaga website.                                               |
| [LoC-LEX-M]        | Template for letter of confirmation for Book-20 LEX-Ms, published on the Zhaga website.                                                   |
| [IEC 60598-1]      | IEC 60598-1, Luminaires – Part 1: General requirements and tests.                                                                         |
| [IEC 60529]        | IEC 60529, Degrees of protection provided by enclosures.                                                                                  |
| [LoC-LEX-LP]       | Template for Letter of confirmation for Book-20 LEX-LP, published on the Zhaga website.                                                   |
| [LoC-LEX-MR]       | Template for Letter of confirmation for Book-20 LEX-MR, published on the Zhaga website.                                                   |

#### 1.4 Definitions

This section defines terms that have a specific meaning in the context of this Book 20. Terms that have a specific meaning across all Zhaga Books are defined in [Book 1].

|                                       |                                                                                  |
|---------------------------------------|----------------------------------------------------------------------------------|
| Luminaire Extension Module            | Module attachable to the Luminaire according to the specifications in this book. |
| Luminaire Extension Slot              | Slot in the Luminaire according to the specifications in this book.              |
| Luminaire Extension Module Receptacle | Module Receptacle according to the specifications in this book.                  |
| Luminaire Extension Luminaire Plug    | Luminaire Plug according to the specifications in this book.                     |
| Luminaire Extension Bus               | Intra Luminaire bus according to the specifications in this book.                |

## 1.5 Acronyms

This section defines acronyms that have a specific meaning in the context of this Book 20. Acronyms that have a specific meaning across all Zhaga Books are defined in [Book 1].

|        |                                       |
|--------|---------------------------------------|
| LEX-M  | Luminaire Extension Module            |
| LEX-S  | Luminaire Extension Slot              |
| LEX-MR | Luminaire Extension Module Receptacle |
| LEX-LP | Luminaire Extension Luminaire Plug    |
| LEX-B  | Luminaire Extension Bus               |

## 1.6 Symbols

Symbols that have a specific meaning across all Zhaga Books are 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 defined requirements provided in Part 1 of this document (i.e. Interface Definition) and the test specifications provided in Part 2 of this document (i.e. Compliance Testing), the test specifications provided in Part 2 take precedence over the requirements 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 20 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 point.

### 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 20 can be found in [Book 1], section 2.

### 2.2 Overview of the indoor connectivity system

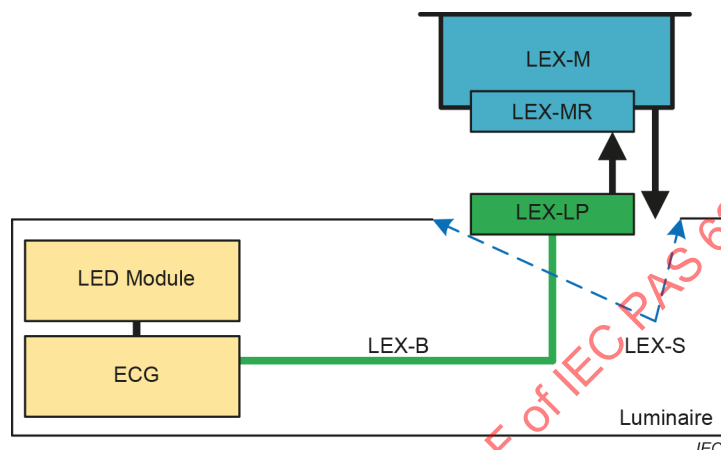


**Figure 2-1 – Schematic overview of a typical Book 20 Luminaire and a Luminaire Extension Module**

A schematic overview of a typical Book 20 Luminaire and a Luminaire Extension Module (LEX-M) is depicted in Figure 2-1.

The Luminaire features:

- An opening in the housing for mounting a Luminaire Extension Module. This opening is denoted Luminaire Extension Slot (LEX-S)
- An ECG with appropriate functionality and a connection to the Luminaire Extension Bus (LEX-B)
- A LEX-B cable with a LEX Luminaire Plug (LEX-LP)

The LEX-M is a separate unit which can easily be mounted in the LEX-S. Typically, it holds additional functionality to enrich the functionality of the total system.

The LEX-M features a Luminaire Extension Module Receptacle (LEX-MR) for mating with the LEX-LP.

This Book 20 defines:

- The mechanical interface of 4 categories of the LEX-M and the LEX-S with different dimensions and identified by designations:
  - R44x17 (rectangular 44x17 mm)
  - R60x22 (rectangular 60x22 mm)
  - C22-T1 (round Ø 22 mm)
  - C22-T2 (round Ø 22 mm)
- The mechanical interface of the LEX-LP
- The mechanical interface of the LEX-MR
- The electrical and communication interface of the LEX-B defined at the interface between LEX-LP and LEX-MR.

## 2.3 Plug-and-play and Performance

The aim of this standard is to enable interoperability by design of the LEX-M and the Luminaire. This means that any LEX-M compliant with this specification is interoperable with any Luminaire compliant with this specification. The specification aims for plug-and-play operation. At the same time, there are no guarantees for the performance of the combination. For example, when adding a presence sensor with a poor performance to the Luminaire the combination will operate but obviously the presence detection will be poor.

## 2.4 Outline of this Book

This Book 20 consists of two parts:

Part 1, Interface Definition, defines the Luminaire/LEX-M interface in terms of the two sub interfaces:

- The mechanical interface (section 3).
- Electrical & Communication Interface (section 4).

Part 2, Compliance Tests, defines:

- Compliance test tools (section 5).
- LEX-MR compliance tests (section 6).
- LEX-LP compliance tests (section 7).
- LEX-M compliance tests (section 8).
- Luminaire compliance tests (section 9).

The Annexes to this Book 20 provide the following additional information:

- Product data set requirements (Annex A).

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## Part 1: Interface Definition

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### 3 Mechanical interface

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

#### 3.1 Drawing principles

The characteristics of the mechanical interface are specified according to the following principles:

- Third angle projection is used.

#### 3.2 Mechanical references

The reference plane, the reference point and the reference axes of LEX-M and LEX-S are defined in Figure 3-1.

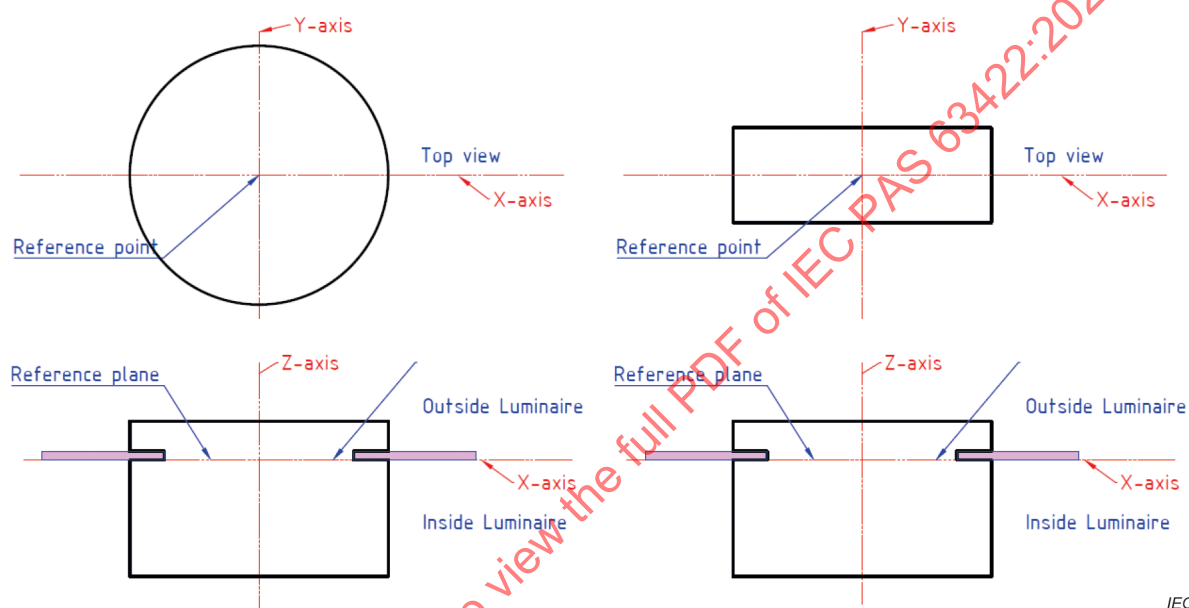


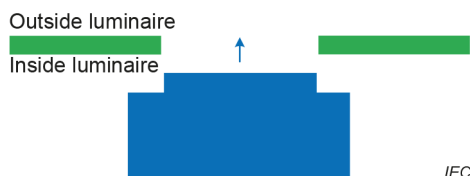
**Figure 3-1 – Positions of the reference point, the reference plane and the reference axes of the LEX-S and LEX-M for circular and rectangular formfactors**

#### 3.3 Overview (informative)

The specification of the mechanical interface allows the LEX-M to be mounted in the Luminaire in three different ways:

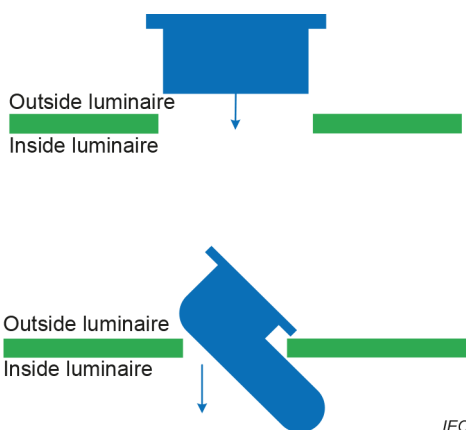
Configuration 1:

- LEX-M is mounted from the inside of the Luminaire into the LEX-S



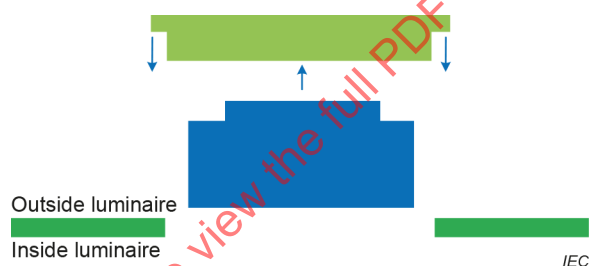
Configuration 2:

- LEX-M is mounted from the outside of the Luminaire into the LEX-S



Configuration 3:

- The Luminaire features an opening larger than LEX-S and a bracket that fits in that opening
- The bracket features a LEX-S
- The LEX-M is mounted from the outside of the Luminaire by
  - Removal of the bracket
  - Attachment of the LEX-M to the bracket
  - Attachment of the bracket + LEX-M to the Luminaire



### 3.4 Method used to specify the mechanical interface of the Luminaire and the LEX-M (informative)

For all categories, specified in this section 3 the same method is used to specify the mechanical interface of the Luminaire and the LEX-M. This method is schematically depicted in Figure 3-2. The following aspects are specified:

- The LEX-S with nominal dimensions + tolerances.
- The thickness of the mounting plate with lower and upper limit.
- Area around the LEX-S where the mounting surface shall be even.
- The demarcation inside the Luminaire and outside the Luminaire.

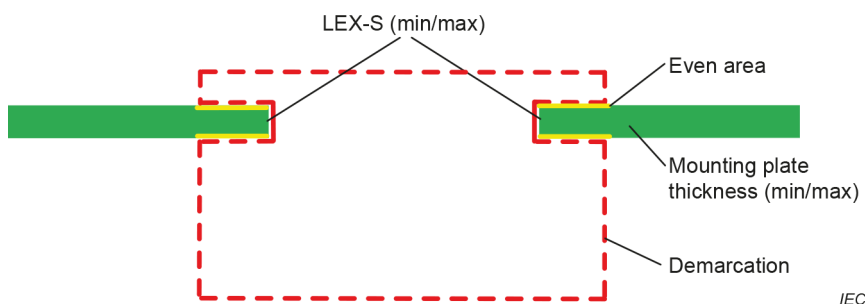


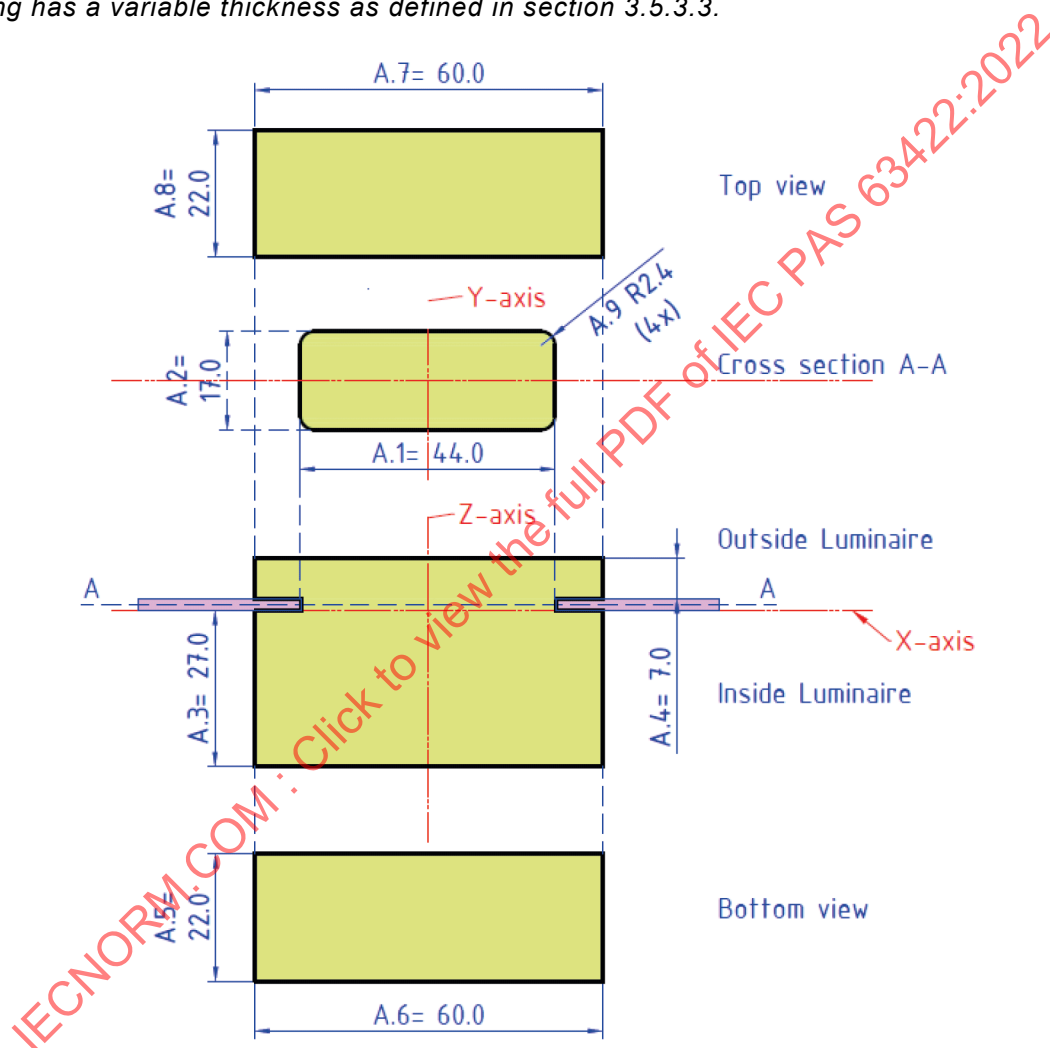
Figure 3-2 – Method of specification of the mechanical interface of the Luminaire and the LEX-M

### 3.5 Mechanical interface of the Luminaire and LEX-M – Category R44x17

#### 3.5.1 LEX-M demarcation model

The geometry of the LEX-M shall be such that the total set of LEX-M + (optional) wire to LEX-MR + LEX-MR + maximum LEX-LP in mated position does not cross the boundaries of the LEX-M Demarcation as defined in Figure 3-3. The keep-in volume for the total set of LEX-M + (optional) wire to LEX-MR + LEX-MR + maximum LEX-LP is indicated by the green area. The maximum size of the LEX-LP is defined in section 3.9.3.2.

*Note that the height of the external part of the demarcation (A.4) is defined with reference to the top surface of the mounting plate whereas the height of the internal part of the demarcation (A.3) is defined with reference to the bottom surface of the mounting plate. The Luminaire housing has a variable thickness as defined in section 3.5.3.3.*



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**Figure 3-3 – Demarcation model for the LEX-M – category R44x17**

Notes to Figure 3-3:

- X-axis, Y-axis and Z-axis are symmetry axes.
- The X-axis, Y-axis and Z-axis in this figure coincide with those in other figures of section 3.5.

#### 3.5.2 Fixation of the LEX-M to the Luminaire

The fixation of the LEX-M to the Luminaire shall be provided by features of the LEX-M and shall not depend on specific features in the Luminaire other than the LEX-S as defined in section 3.5.3.3.

The means of fixation implemented in the LEX-M shall be such that the LEX-M can be detached from the Luminaire without damaging the LEX-M nor the Luminaire.

The means of fixation implemented in the LEX-M shall be such that it works for all thicknesses of the mounting plate within the allowed range as defined in section 3.5.3.3.

### 3.5.3 Luminaire

#### 3.5.3.1 Multiple LEX-Bs

The Luminaire may hold multiple sections with independent LEX-Bs, each connecting ECGs, Bus Power supply unit and one LEX-LP. In this case, each section of the Luminaire shall comply with all the requirements for Luminaires and LEX-S in sections 3.5.3.2 and 3.5.3.3 .

#### 3.5.3.2 General

The Luminaire shall provide at least one LEX-S according to the definitions in section 3.5.3.3.

The Luminaire shall provide exactly one LEX Luminaire Plug according to the definitions in section 3.9.3.

The Luminaire (including optional bracket) shall not cross the boundaries of the LEX-M Demarcation as defined in Figure 3-3. The keep-out volume for the Luminaire is indicated by the green area.

#### 3.5.3.3 Luminaire Extension Slot (LEX-S)

The Luminaire or the bracket shall have a LEX-S with dimensions as depicted in Figure 3-4. The thickness of the mounting plate shall be in the range  $0.4 \leq D \leq 1.5$  mm and the typical value is 0.7 mm.

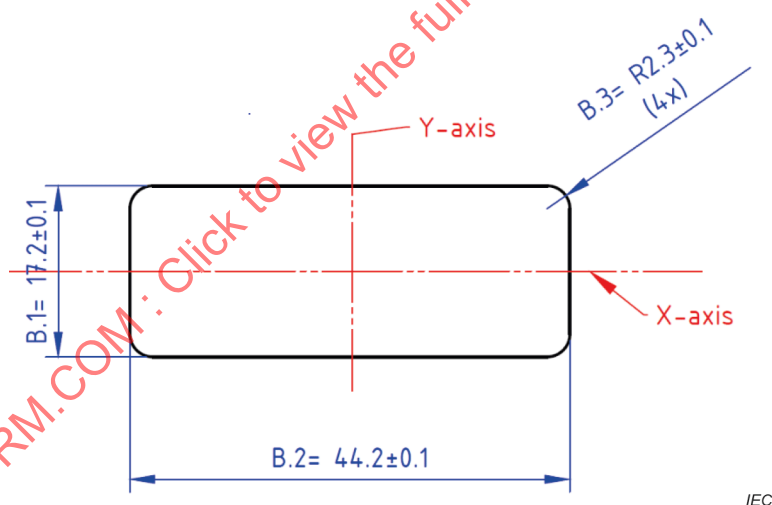


Figure 3-4 – Dimensions of the LEX-S– category R44x17

Notes to Figure 3-4:

- X-axis and Y-axis are symmetry axes.
- The X-axis and Y-axis in this figure coincide with those in other figures of section 3.5.

The surrounding area of the LEX-S as indicated in yellow in Figure 3-5 shall have an even surface at the exterior of the Luminaire as well as at the interior of the Luminaire.

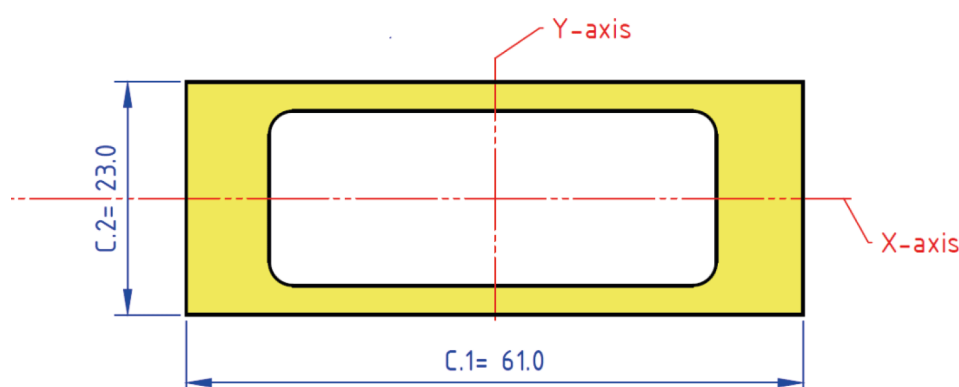


**Figure 3-5 – Border of the LEX-S – category R44x17**

Notes to Figure 3-5:

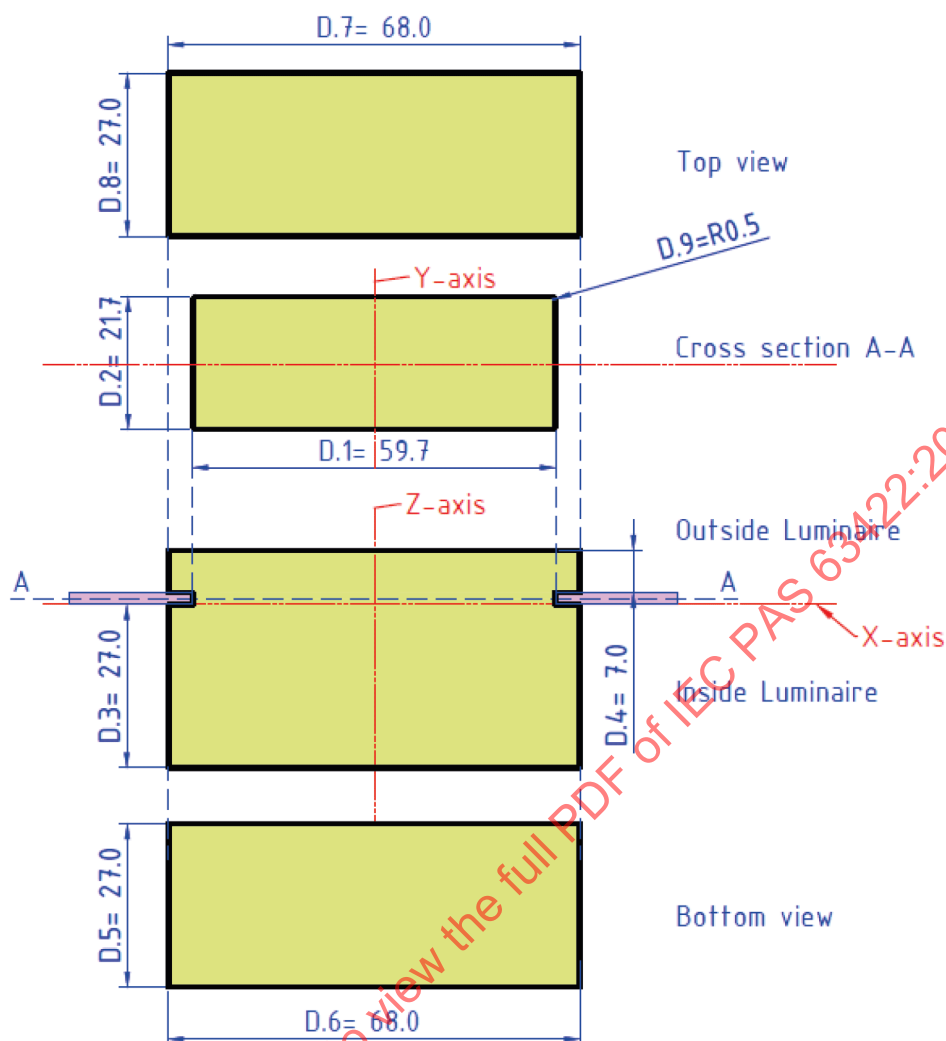
- X-axis and Y-axis are symmetry axes.
- The X-axis and Y-axis in this figure coincide with those in other figures of section 3.5.

### **3.6 Mechanical interface of the Luminaire and LEX-M – category R60x22**

#### **3.6.1 LEX-M demarcation model**

The geometry of the LEX-M shall be such that the total set of LEX-M + (optional) wire to LEX-MR + LEX-MR + maximum LEX-LP in mated position does not cross the boundaries of the LEX-M Demarcation as defined in Figure 3-6. The keep-in volume for the total set of LEX-M + (optional) wire to LEX-MR + LEX-MR + maximum LEX-LP is indicated by the green area. The maximum size of the LEX-LP is defined in section 3.9.3.2.

*Note that the height of the external part of the demarcation (D.4) is defined with reference to the top surface of the mounting plate whereas the height of the internal part of the demarcation (D.3) is defined with reference to the bottom surface of the mounting plate. The Luminaire housing has a variable thickness as defined in section 3.6.3.3.*



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**Figure 3-6 – Demarcation model for the LEX-M – category R60x22**

Notes to Figure 3-6:

- X-axis, Y-axis and Z-axis are symmetry axes.
- The X-axis, Y-axis and Z-axis in this figure coincide with those in other figures of section 3.6.

### 3.6.2 Fixation of the LEX-M to the Luminaire

The fixation of the LEX-M to the Luminaire shall be provided by features of the LEX-M and shall not depend on specific features in the Luminaire other than the LEX-S as defined in section 3.6.3.3.

The means of fixation implemented in the LEX-M shall be such that the LEX-M can be detached from the Luminaire without damaging the LEX-M nor the Luminaire.

The means of fixation implemented in the LEX-M shall be such that it works for all thicknesses of the mounting plate within the allowed range as defined in section 3.6.3.3.

### 3.6.3 Luminaire

#### 3.6.3.1 Multiple LEX-Bs

The Luminaire may hold multiple sections with independent LEX-Bs, each connecting ECGs, Bus Power supply unit and one LEX-LP. In this case, each section of the Luminaire shall comply with all the requirements for Luminaires and LEX-S in sections 3.6.3.2 and 3.6.3.3.

### 3.6.3.2 General

The Luminaire shall provide at least one LEX-S according to the definitions in section 3.6.3.3.

The Luminaire shall provide exactly one LEX Luminaire Plug according to the definitions in section 3.9.3.

The Luminaire (including optional bracket) shall not cross the boundaries of the LEX-M Demarcation as defined in Figure 3-6. The keep-out volume for the Luminaire is indicated by the green area.

### 3.6.3.3 Luminaire Extension Slot (LEX-S)

The Luminaire or the bracket shall have a LEX-S with dimensions as depicted in Figure 3-7. The thickness of the mounting plate shall be in the range  $0.4 \leq D \leq 1.5$  mm and the typical value is 0.7 mm.

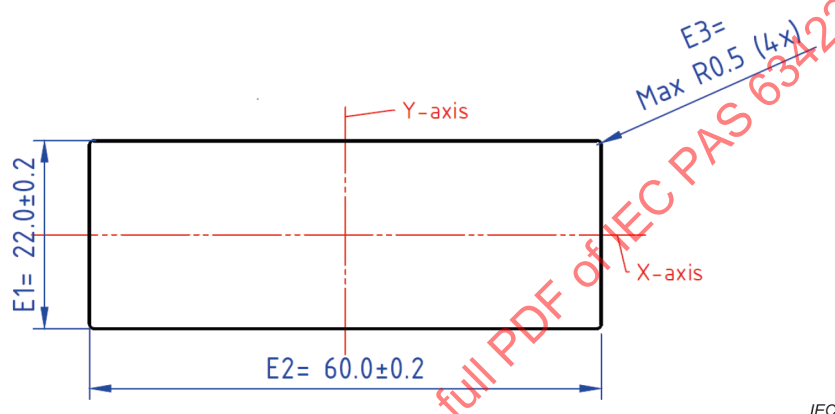


**Figure 3-7 – Dimensions of the LEX-S – category R60x22**

Notes to Figure 3-7:

- X-axis and Y-axis are symmetry axes.
- The X-axis and Y-axis in this figure coincide with those in other figures of section 3.6.

The surrounding area of the LEX-S as indicated in yellow in Figure 3-8 shall have an even surface at the exterior of the Luminaire as well as at the interior of the Luminaire.

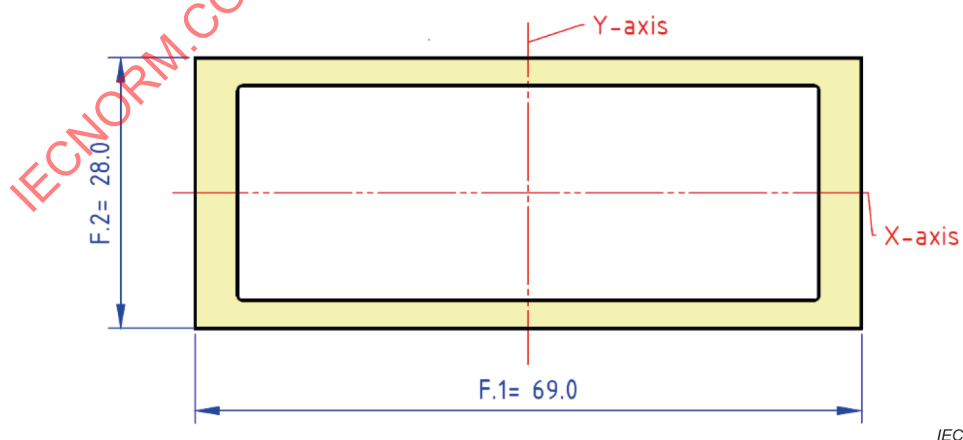


**Figure 3-8 – Border of the LEX-S – category R60x22**

Notes to Figure 3-8:

- X-axis and Y-axis are symmetry axes.
- The X-axis and Y-axis in this figure coincide with those in other figures of section 3.6.

### 3.7 Mechanical interface of the Luminaire and LEX-M – category C22-T1

#### 3.7.1 LEX-M demarcation model

The geometry of the LEX-M shall be such that the total set of LEX-M + (optional) wire to LEX-MR + LEX-MR + maximum LEX-LP in mated position does not cross the boundaries of the LEX-M Demarcation as defined in Figure 3-9. The keep-in volume for the total set of LEX-M + (optional) wire to LEX-MR + LEX-MR + maximum LEX-LP is indicated by the green area. The maximum size of the LEX-LP is defined in section 3.9.3.2.

*Note that the height of the external part of the demarcation (G.3) is defined with reference to the top surface of the mounting plate whereas the height of the internal part of the demarcation (G.2) is defined with reference to the bottom surface of the mounting plate. The Luminaire housing has a variable thickness as defined in section 3.7.3.3.*

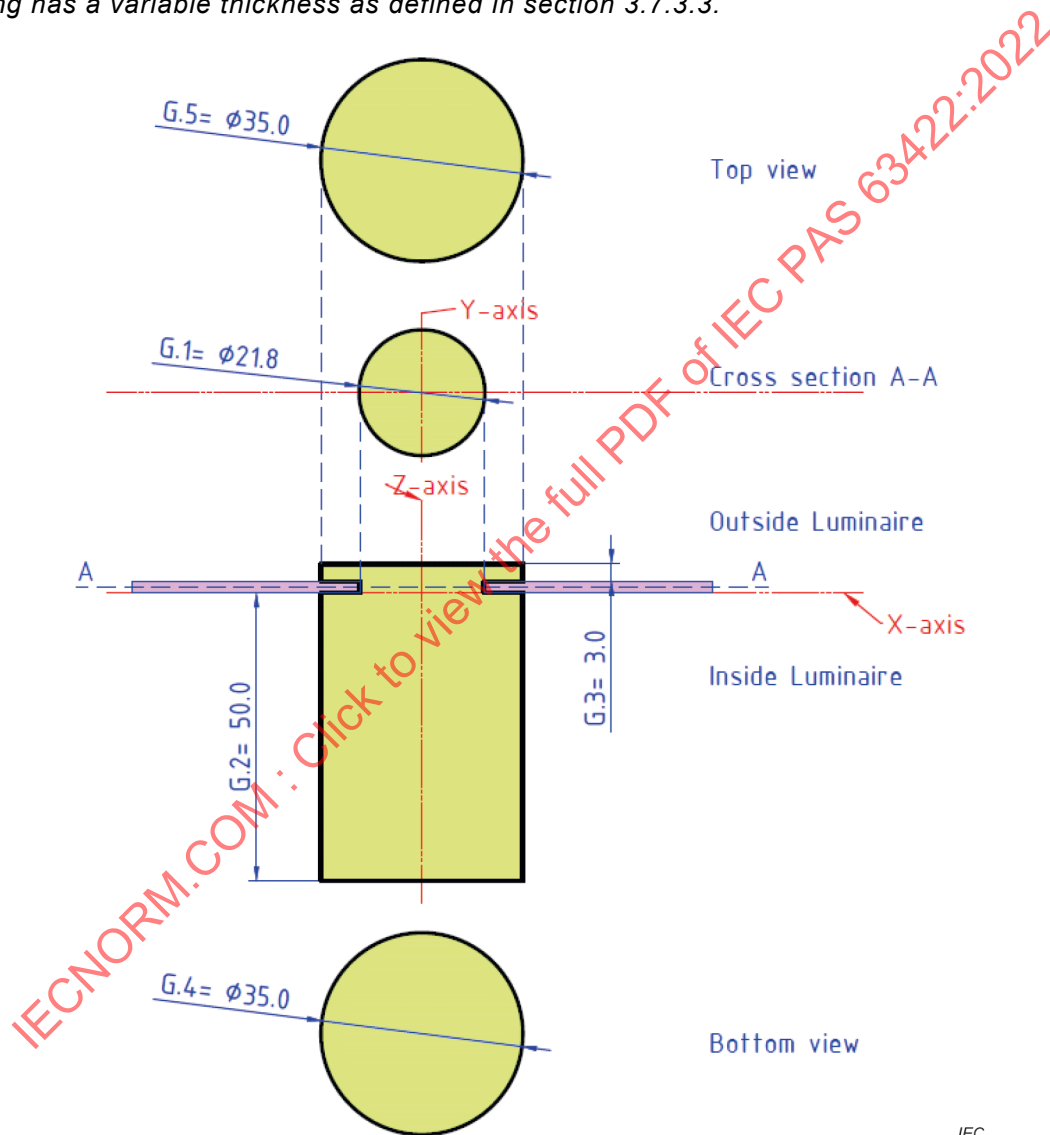


**Figure 3-9 – Demarcation model for the LEX-M – category C22-T1**

Notes to Figure 3-9:

- X-axis, Y-axis and Z-axis are symmetry axes.
- The X-axis, Y-axis and Z-axis in this figure coincide with those in other figures of section 3.7.

### 3.7.2 Fixation of the LEX-M to the Luminaire

The fixation of the LEX-M to the Luminaire shall be provided by features of the LEX-M and shall not depend on specific features in the Luminaire other than the LEX-S as defined in section 3.7.3.3.

The means of fixation implemented in the LEX-M shall be such that the LEX-M can be detached from the Luminaire without damaging the LEX-M nor the Luminaire.

The means of fixation implemented in the LEX-M shall be such that it works for all thicknesses of the mounting plate within the allowed range as defined in section 3.7.3.3.

### 3.7.3 Luminaire

#### 3.7.3.1 Multiple LEX-Bs

The Luminaire may hold multiple sections with independent LEX-Bs, each connecting ECGs, Bus Power supply unit and one LEX-LP. In this case, each section of the Luminaire shall comply with all the requirements for Luminaires and LEX-S in sections 3.7.3.2 and 3.7.3.3.

#### 3.7.3.2 General

The Luminaire shall provide at least one LEX-S according to the definitions in section 3.7.3.3.

The Luminaire shall provide exactly one LEX Luminaire Plug according to the definitions in section 3.9.3.

The Luminaire (including optional bracket) shall not cross the boundaries of the LEX-M Demarcation defined in Figure 3-9. The keep-out volume for the Luminaire is indicated by the green area.

#### 3.7.3.3 Luminaire Extension Slot (LEX-S)

The Luminaire or the bracket shall have a LEX-S with dimensions as depicted in Figure 3-10. The thickness of the mounting plate shall be in the range  $0.4 \leq D \leq 1.5$  mm and the typical value is 0.7 mm.

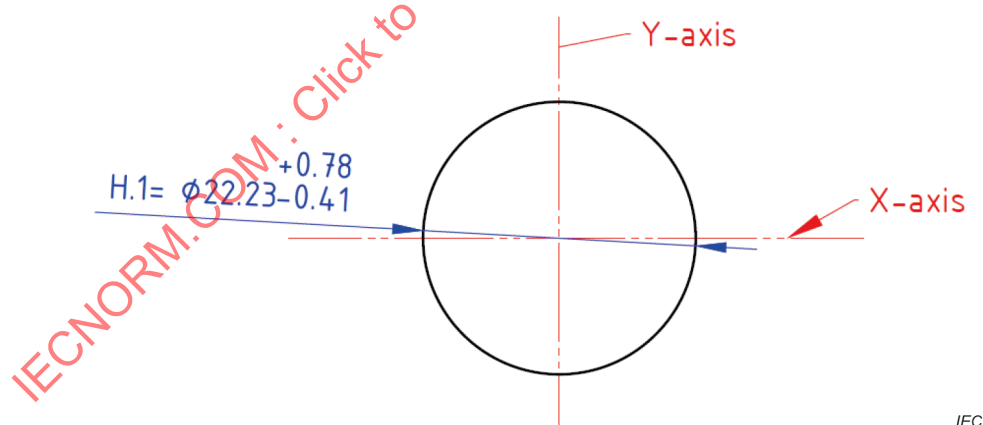


**Figure 3-10 – Dimensions of the LEX-S– category C22-T1**

Notes to Figure 3-10:

- X-axis and Y-axis are symmetry axes.
- The X-axis and Y-axis in this figure coincide with those in other figures of section 3.7.

The surrounding area of the LEX-S as indicated in yellow in Figure 3-11 shall have an even surface at the exterior of the Luminaire as well as at the interior of the Luminaire.

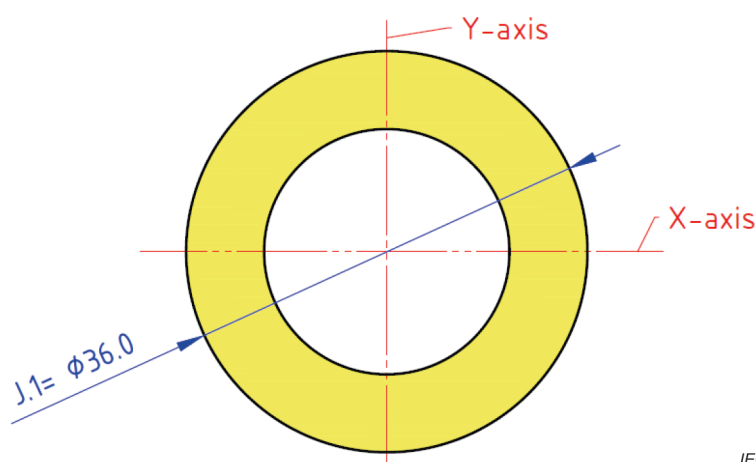


**Figure 3-11 – Border of the LEX-S – category C22-T1**

Notes to Figure 3-11:

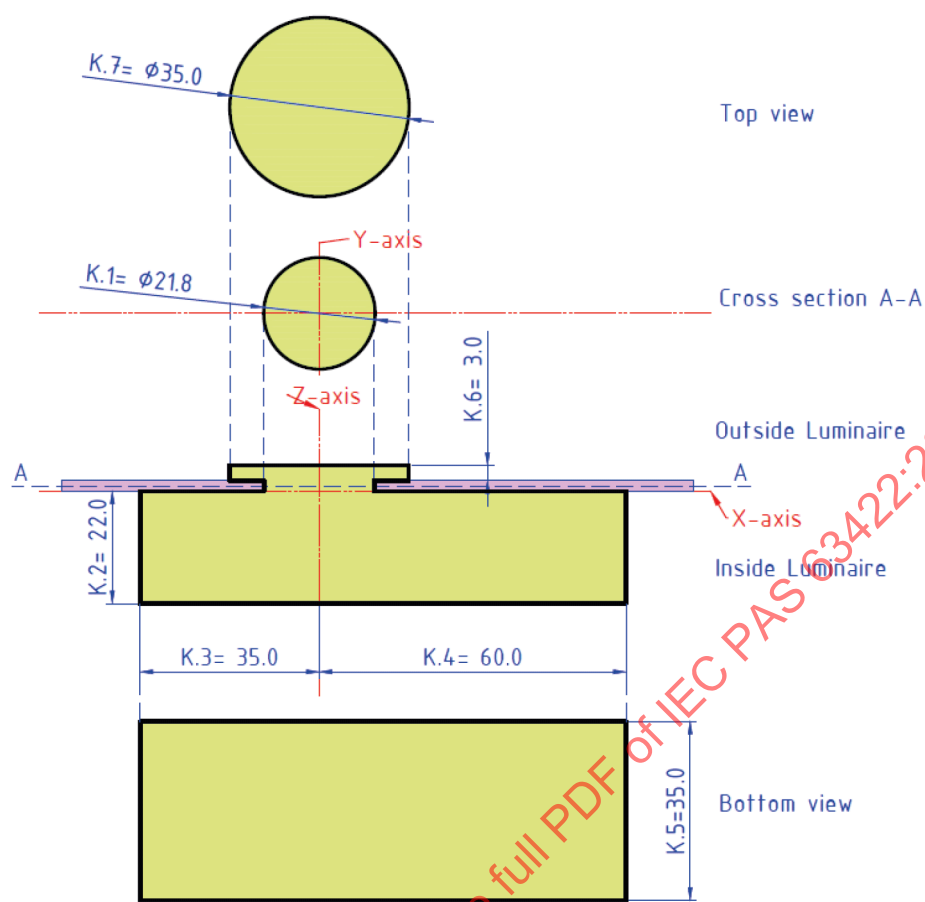
- X-axis and Y-axis are symmetry axes.
- The X-axis and Y-axis in this figure coincide with those in other figures of section 3.7.

### **3.8 Mechanical interface of the Luminaire and LEX-M – category C22-T2**

#### **3.8.1 LEX-M demarcation model**

The geometry of the LEX-M shall be such that the total set of LEX-M + (optional) wire to LEX-MR + LEX-MR + maximum LEX-LP in mated position does not cross the boundaries of the LEX-M Demarcation as defined in Figure 3-12. The keep-in volume for the total set of LEX-M + (optional) wire to LEX-MR + LEX-MR + maximum LEX-LP is indicated by the green area. The maximum size of the LEX-LP is defined in section 3.9.3.2.

*Note that the height of the external part of the demarcation (K.6) is defined with reference to the top surface of the mounting plate whereas the height of the internal part of the demarcation (K.2) is defined with reference to the bottom surface of the mounting plate. The Luminaire housing has a variable thickness as defined in section 3.8.3.3.*



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**Figure 3-12 – Demarcation model for the LEX-M – category C22-T2**

Notes to Figure 3-12:

- X-axis, Y-axis and Z-axis are symmetry axes.
- The X-axis, Y-axis and Z-axis in this figure coincide with those in other figures of section 3.8.

### 3.8.2 Fixation of the LEX-M to the Luminaire

The fixation of the LEX-M to the Luminaire shall be provided by features of the LEX-M and shall not depend on specific features in the Luminaire other than the LEX-S as defined in section 3.8.3.3.

The means of fixation implemented in the LEX-M shall be such that the LEX-M can be detached from the Luminaire without damaging the LEX-M nor the Luminaire.

The means of fixation implemented in the LEX-M shall be such that it works for all thicknesses of the mounting plate within the allowed range as defined in section 3.8.3.3.

### 3.8.3 Luminaire

#### 3.8.3.1 Multiple LEX-Bs

The Luminaire may hold multiple sections with independent LEX-Bs, each connecting ECGs, Bus Power supply unit and one LEX-LP. In this case, each section of the Luminaire shall comply with all the requirements for Luminaires and LEX-S in sections 3.8.3.2 and 3.8.3.3.

#### 3.8.3.2 General

The Luminaire shall provide at least one LEX-S according to the definitions in section 3.8.3.3.

The Luminaire shall have exactly one LEX Luminaire Plug according to the definitions in section 3.9.3.

The Luminaire (including optional bracket) shall not cross the boundaries of the LEX-M Demarcation defined in Figure 3-12. The keep-out volume for the Luminaire is indicated by the green area.

### 3.8.3.3 Luminaire Extension Slot (LEX-S)

The Luminaire or the bracket shall have a LEX-S with dimensions as depicted in Figure 3-13. The thickness of the mounting plate shall be in the range  $0.4 \leq D \leq 1.5$  mm and the typical value is 0.7 mm.

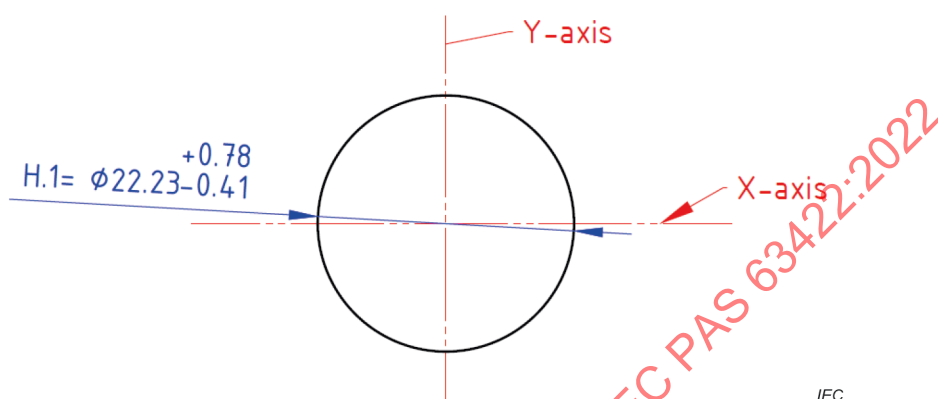


**Figure 3-13 – Dimensions of the LEX-S – category C22-T2**

Notes to Figure 3-13:

- X-axis and Y-axis are symmetry axes.
- The X-axis and Y-axis in this figure coincide with those in other figures of section 3.8.

The surrounding area of the LEX-S as indicated in yellow in Figure 3-14 shall have an even surface at the exterior of the Luminaire.

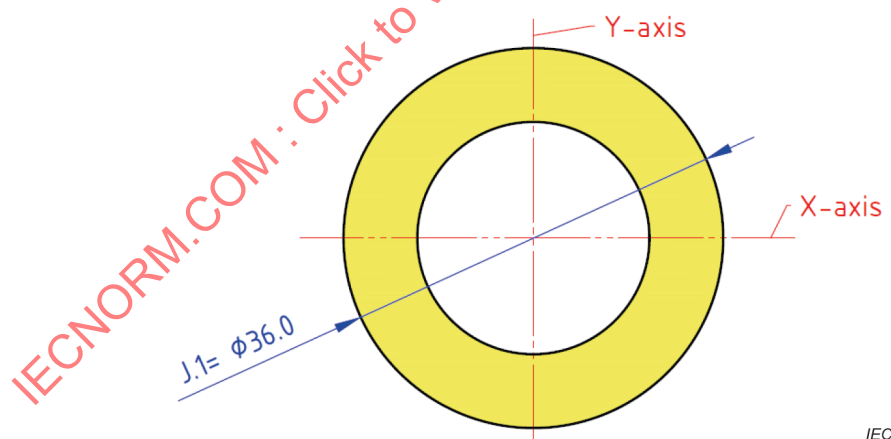


**Figure 3-14 – Border of the LEX-S – category C22-T2**

Notes to Figure 3-14:

- X-axis and Y-axis are symmetry axes.
- The X-axis and Y-axis in this figure coincide with those in other figures of section 3.8.

The surrounding area of the LEX-S as indicated in yellow in Figure 3-15 shall have an even surface at the interior of the Luminaire.

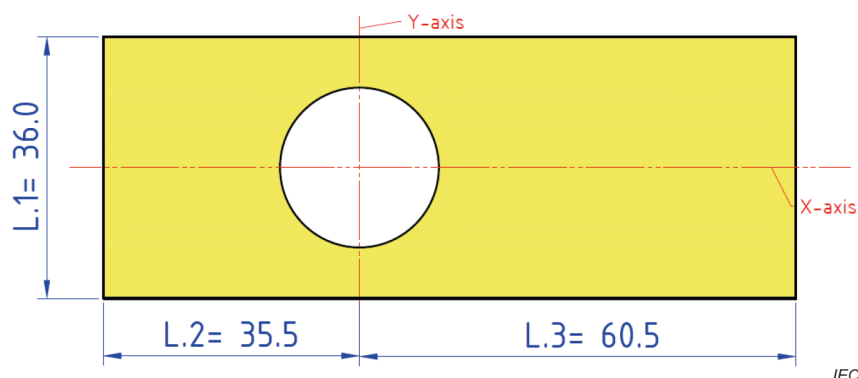


**Figure 3-15 – Internal border of the LEX-S – category C22-T2**

Notes to Figure 3-15:

- X-axis and Y-axis are symmetry axes.
- The X-axis and Y-axis in this figure coincide with those in other figures of section 3.8.

### 3.9 Mechanical interface of the LEX-MR and LEX-LP

#### 3.9.1 Overview (informative)

A schematic overview of the connection system of the LEX-M is depicted in Figure 3-16. This connection system consists of a LEX-MR and a LEX-LP. This specification is intended to support two configurations:

- Wire-to-board configuration, shown on the left side in Figure 3-16. In this case the LEX-MR is fixed to the LEX-M.
- Wire-to-wire configuration, shown on the right side in Figure 3-16. In this case the LEX-MR is connected to the LEX-M via a wire.

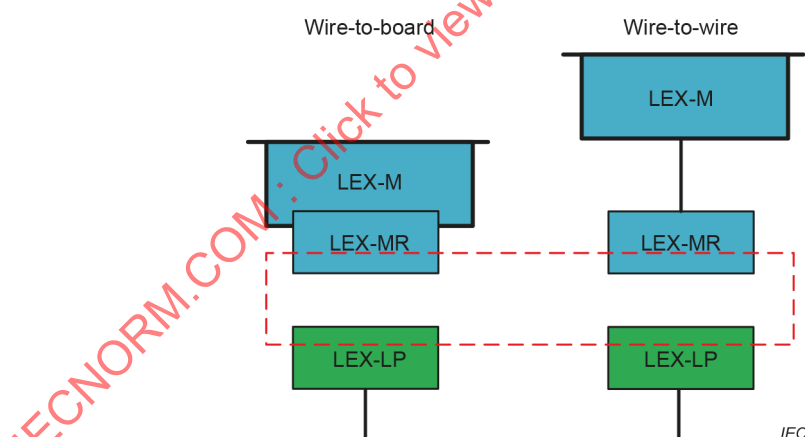
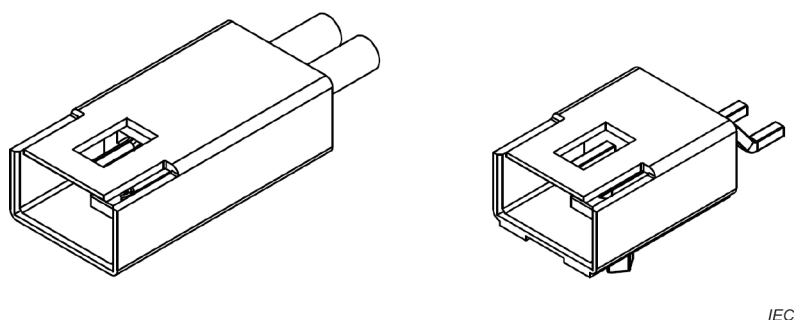


**Figure 3-16 – Supported configurations and scope of the specification**

This specification defines the interface indicated in Figure 3-16 by the red dashed box further referred to as the mating area. On top of that, the maximum sizes of the LEX-LP and the LEX-MR are specified. Apart from that, the designs of the LEX-MR and the LEX-LP are not restricted.

#### 3.9.2 LEX Module Receptacle (LEX-MR)

For illustration purposes, examples of the wire-to-wire LEX-MR (left) and the wire-to-board LEX-MR (right) are shown in Figure 3-17. These drawings are informative and not part of the specification.

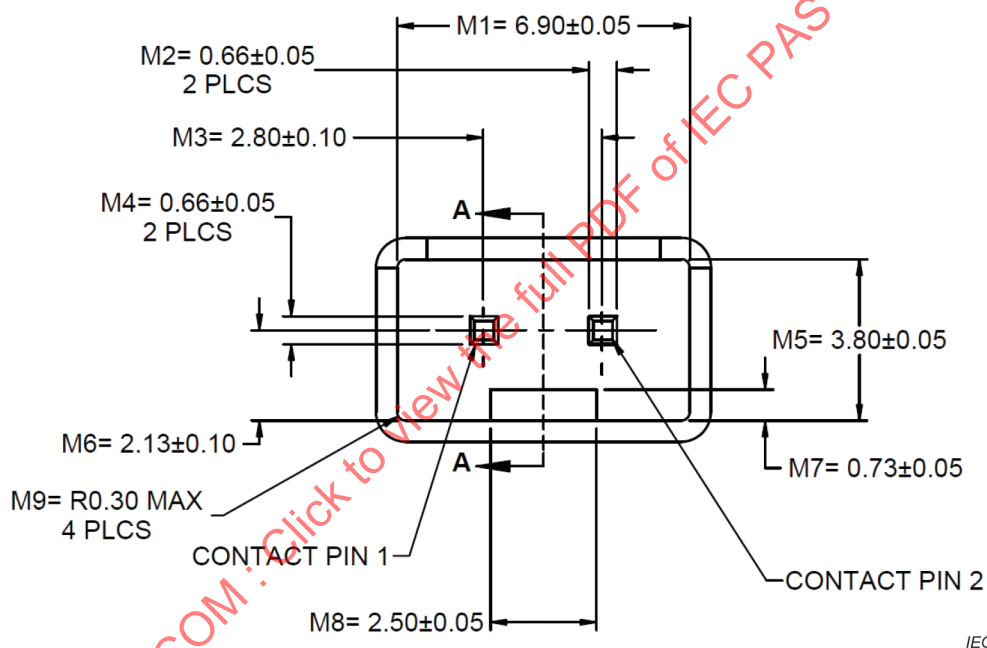


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**Figure 3-17 – Examples of the wire-to-wire LEX-MR and the wire-to-board LEX-MR (informative)**

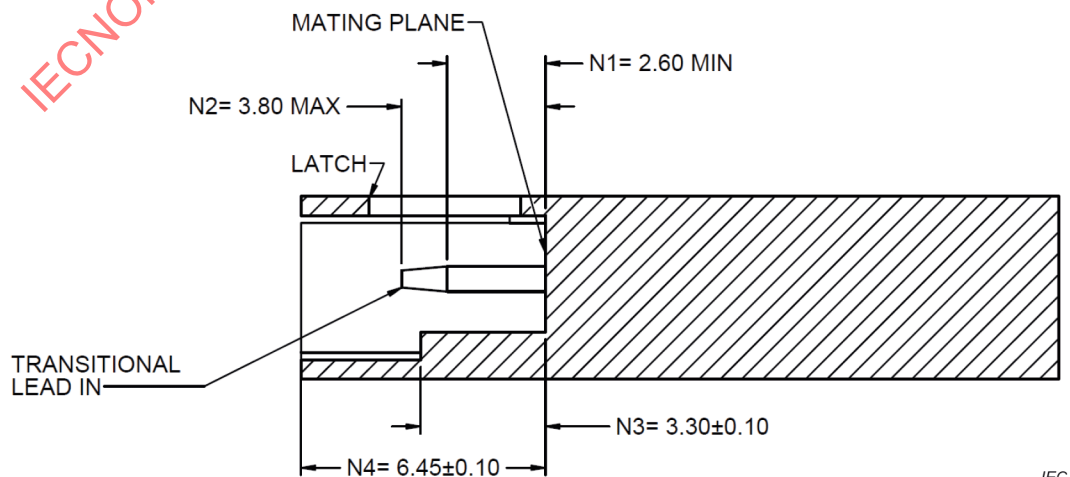
### 3.9.2.1 LEX-MR mating area

The LEX-MR shall comply with the definitions in Figure 3-18 and Figure 3-19



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**Figure 3-18 – Mechanical interface of the mating area of the LEX-MR**



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**Figure 3-19 – Mechanical interface of the mating area of the LEX-MR – cross section A-A**

Both contact pins shall be coined on all 4 sides of the pins.

### 3.9.2.2 LEX-MR wire-to-wire demarcation model

In case the LEX-MR is of type wire-to-wire, it shall not cross the boundaries of the LEX-MR Demarcation as defined in Figure 3-20. The keep-in volume for the LEX-MR is indicated by the green area.

*Note that the maximum length in this demarcation model is defined with reference to the mating plane.*

*Note that the keep-in volume does not include the volume that is necessary for the wires. The Luminaire maker should reserve some extra space for this.*

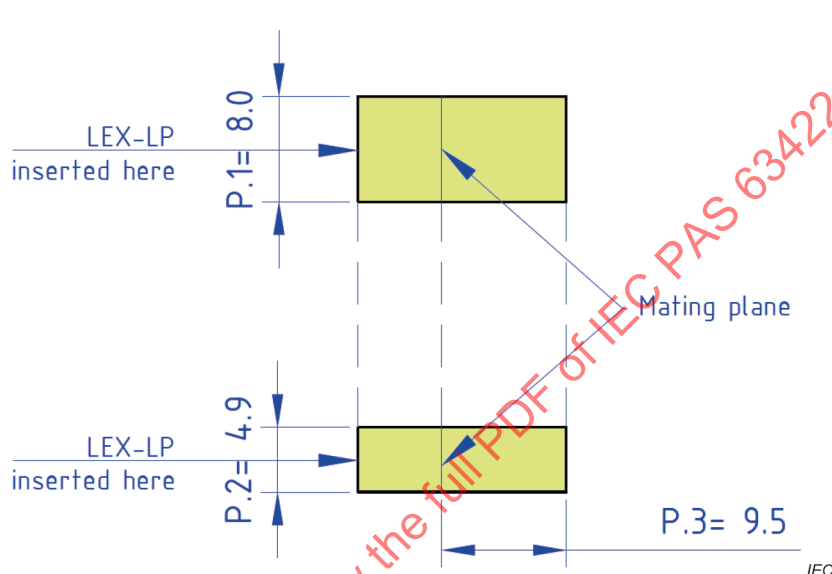


**Figure 3-20 – Demarcation model of the LEX-MR  
(top view and side view) – wire-to-wire type**

### 3.9.2.3 LEX-MR wire-to-board demarcation model

In case the LEX-MR is of type wire-to-board, it shall not cross the boundaries of the LEX-MR Demarcation as defined in Figure 3-21. The keep-in volume for the LEX-MR is indicated by the green area. When checking compliance with the demarcation model, the possible alignment pins and contact pins which are intended to be plugged in the PCB of the LEX-M shall be ignored.

*Note that the maximum length in this demarcation model is defined with reference to the mating plane.*

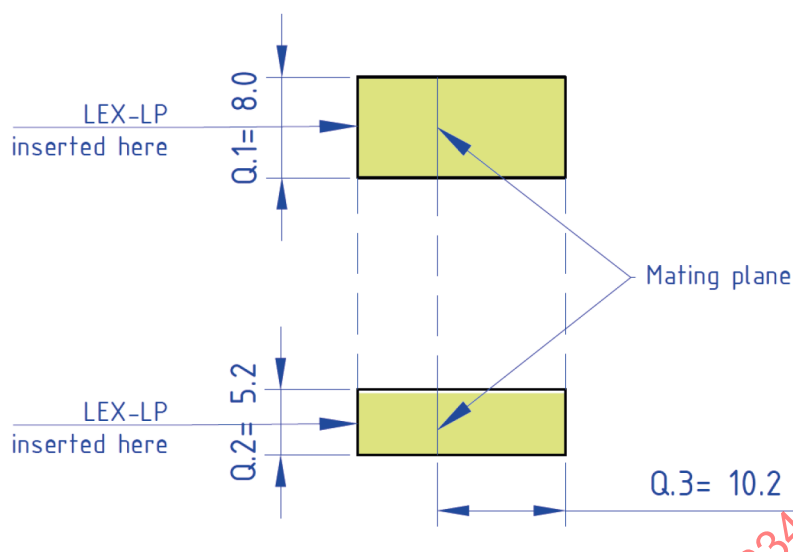


**Figure 3-21 – Demarcation model of the LEX-MR (top view and side view) – wire-to-board type**

### 3.9.2.4 LEX-MR additional requirements

After 10 mating cycles with the gauge defined in section 5.1, the force for un-mating shall be 5 N or more.

Both contact pins of the LEX-MR shall be completely tin plated.

When the gauge defined in section 5.1 is fully inserted in the LEX-MR, the latch-on pin housing of the LEX-MR shall not be bent up.

### 3.9.3 LEX Luminaire Plug (LEX-LP)

For illustration purposes, an example of a LEX-LP is shown in the 3D drawing in Figure 3-22. This drawing is informative and not part of the specification.

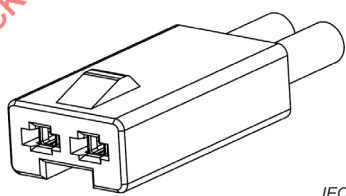


**Figure 3-22 – Examples of a LEX-LP (informative)**

#### 3.9.3.1 LEX-LP mating area

The LEX-LP shall comply with the definitions in Figure 3-23 and Figure 3-24.

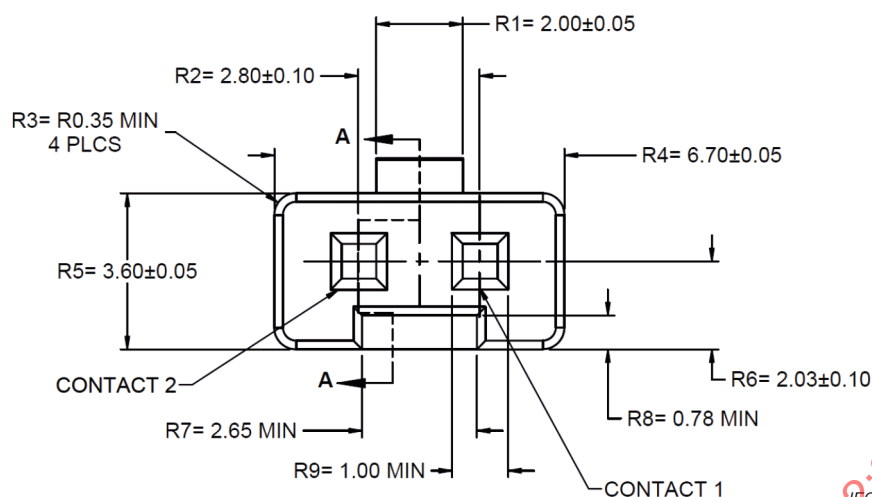


**Figure 3-23 – Mechanical interface of the mating area of the LEX-LP**

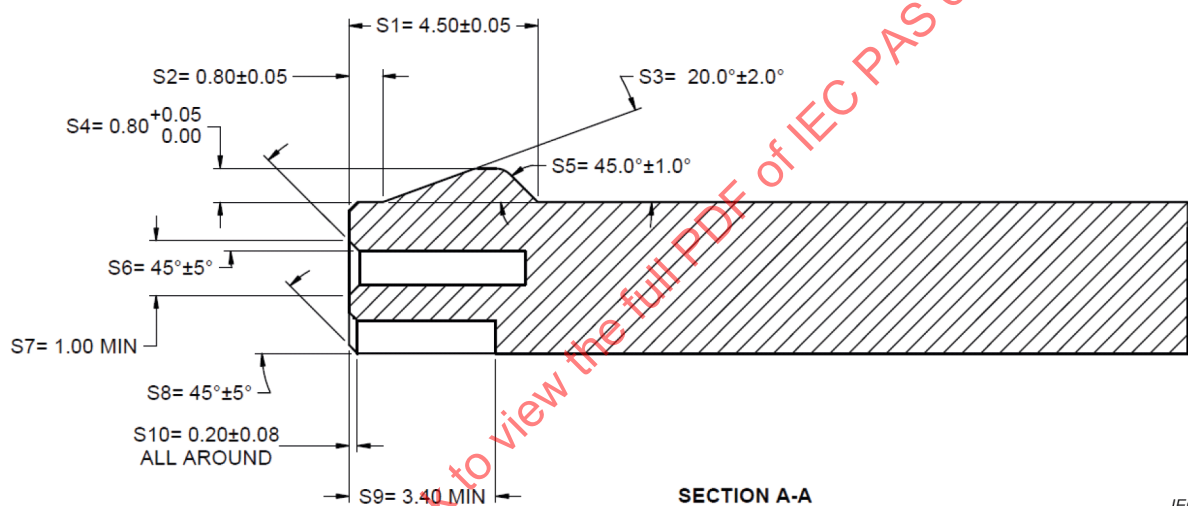


**Figure 3-24 – Mechanical interface of the mating area of the LEX-LP – cross section A-A**

### 3.9.3.2 LEX-LP demarcation model

Except for the detent element, the LEX-LP shall not cross the boundaries of the LEX-LP Demarcation as defined in Figure 3-25. The keep-in volume for the LEX-LP is indicated by the green area. At the position of the retention feature the maximum height is restricted to 4.5 mm instead of 3.7 mm.

*Note that the keep-in volume does not includes the volume that is necessary for the wires. The Luminaire maker should reserve some extra space for this.*

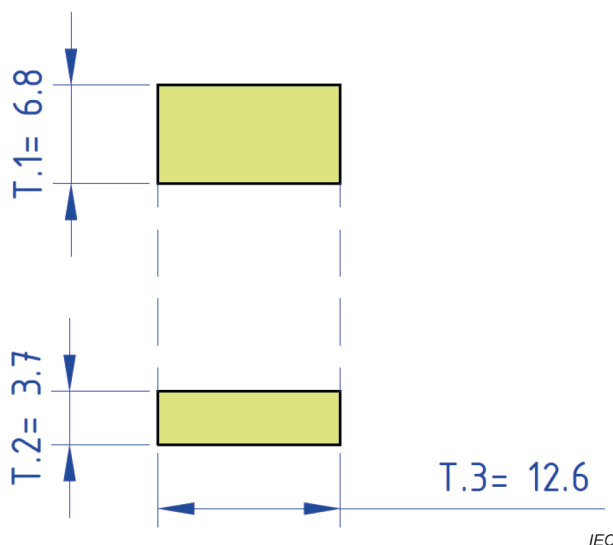


**Figure 3-25 – Demarcation model of the LEX-LP (top view and side view)**

### 3.9.3.3 LEX-LP additional requirements

Both contacts of the LEX-LP shall be completely tin plated.

## 4 Electrical & Communication Interface

### 4.1 Overview (Informative)

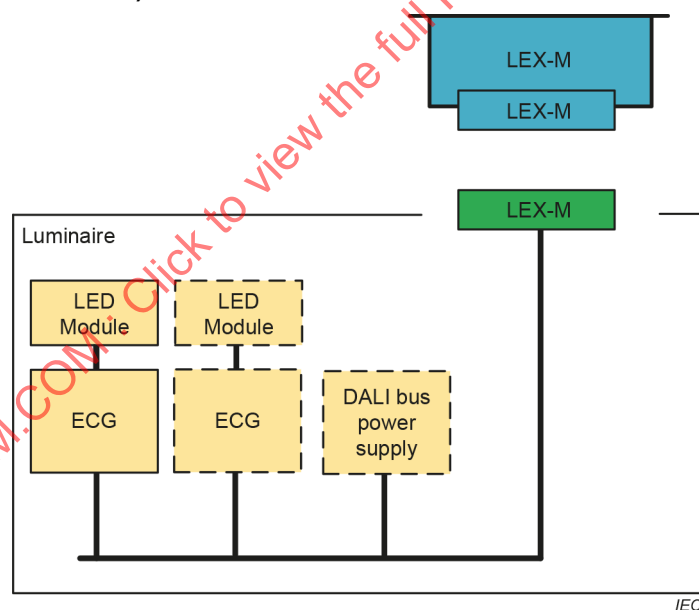


**Figure 4-1 – Overview of the LEX-M and the Luminaire with LEX-LP**

An overview of a typical Luminaire with LEX-LP and the LEX-M with LEX-MR is depicted in Figure 4-1. The Luminaire holds one to four ECGs driving the LED Modules and one LEX-LP. Additionally, the Luminaire provides DALI bus power supply which may be integrated in the ECG or in a separate bus power supply unit.

The specification in this section 4 aims for plug-and-play. In the context of this specification, plug-and-play means that the total system functions as specified in the datasheets of the Luminaire and the LEX-M. It does not guarantee performance (e.g. sensitivity of a presence detector).

In this edition of the specification, the system is restricted to Luminaires without internal DALI application controllers or input devices and to Luminaires that do not provide provisions for connection to an external DALI bus.

## 4.2 Multiple LEX-Bs

The Luminaire may hold multiple sections with independent LEX-Bs, each connecting ECGs, Bus Power supply unit and one LEX-LP. In this case, each section of the Luminaire shall comply with all the requirements for Luminaires and LEX-LP in sections 4.3, 4.4, 4.5, 4.6 and 4.7.

## 4.3 General

The Luminaire shall meet all requirements for Luminaires as defined in section 7 of [D4i Requirements].

ECGs and Bus power supply units shall be in the Luminaire. It is not allowed that these components are attached to the Luminaire.

## 4.4 Pin assignment at the Luminaire Extension Interface

The contacts of the LEX-LP of the Luminaire shall be connected to the LEX-B according to the assignments as indicated in Table 4-1.

The contact pins of the LEX-MR shall be connected to the rest of the LEX-M system according to the assignments as indicated in Table 4-1.

**Table 4-1 – Assignments of contacts in the LEX-MR and in the LEX-LP**

| LEX-MR contact number with reference to Figure 3-18 | LEX-LP contact number with reference to Figure 3-23 | Assignment                                                     |
|-----------------------------------------------------|-----------------------------------------------------|----------------------------------------------------------------|
| 1                                                   | 1                                                   | • DA- (Negative pole for the DALI communication and bus power) |
| 2                                                   | 2                                                   | • DA+ (Positive pole for the DALI communication and bus power) |

## 4.5 Contact resistance of the LEX-LP

Each contact of the LEX-LP shall allow for a contact resistance less than 500 mΩ when mated with the contact making gauge as defined in section 5.2.

## 4.6 Electrical insulation at the Luminaire Extension Interface

*Safety requirements for devices are covered by IEC standards and national regulations and compliance with these standards and regulations is the responsibility of the manufacturers.*

### 4.6.1 Insulation requirements for the LEX-LP

All contacts of the LEX-LP shall be insulated versus mains power according to the requirements for basic insulation as defined in IEC 60598-1.

*Note: All contacts of the LEX-LP may in addition be insulated versus mains power according to the requirements as defined in regional standards or regulations, e.g. UL 1310.*

The design of the LEX-LP should be such that any conductive part of the LEX-LP cannot be touched with a straight unjointed test finger having the same dimensions as the standard test finger specified in [IEC 60529].

When no LEX-M is mounted, a cover should be mounted to the LEX-S to ensure sufficient protection against pollution, damage and electrical shock.

### 4.6.2 Insulation requirements for the LEX-M

The LEX-M should provide supplementary insulation as defined in [IEC 60598-1] between its interface contacts and touchable conductive parts when the LEX-M is attached to the Luminaire.

## **4.7 DALI communication & DALI bus power at the Luminaire Extension Interface**

### **4.7.1 DALI communication & DALI bus power requirements for the LEX-LP**

At the LEX-LP of the Luminaire, the Luminaire shall be capable to provide DALI signals and DALI bus power supply. On top of the requirements for Luminaires as defined in [D4i Requirements], the following requirements shall be met.

- All non-emergency ECGs installed in the Luminaire shall be connected to the LEX-B.
- The (optional) bus power supply unit in the Luminaire shall be connected to the LEX-B.
- The Luminaire excluding the LEX-M shall not comprise DALI application controllers nor DALI input devices as defined in [DALI – Part 103].
- The Luminaire shall not feature provisions for connection to an external DALI bus.
- At the LEX-LP interface, the guaranteed supply current provided shall be at least 48 mA and the maximum supply current shall not exceed 250 mA.

### **4.7.2 DALI communication & DALI bus power requirements for the LEX-M**

The LEX-M shall meet the requirements for a Type C control device, or a bus powered Type D control device as defined in [DALI – Part 351] (Luminaire mounted control devices).

The LEX-M shall be listed as D4i certified [D4i Requirements] in the DiiA database [DiiA Database].

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## Part 2: Compliance Tests

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## 5 Compliance test tools

### 5.1 GO-Gauge for the LEX-MR

#### 5.1.1 Mechanical drawings of the GO-Gauge for LEX-MR

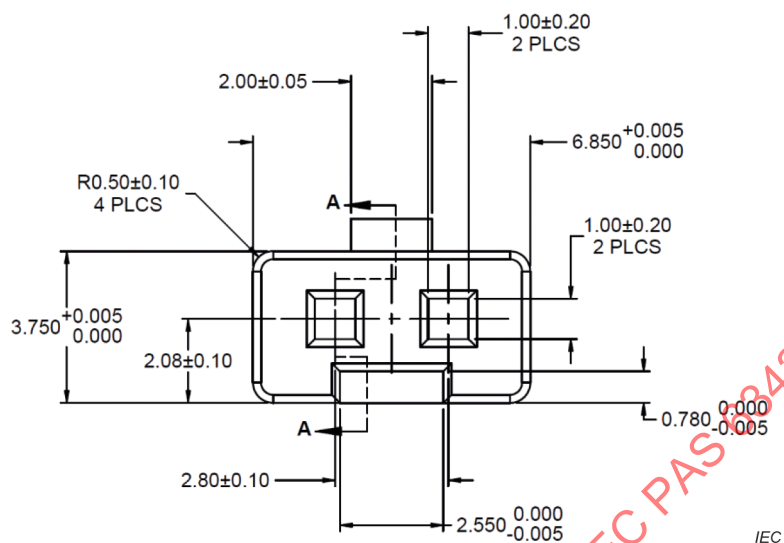


Figure 5-1 – Mechanical interface of the mating area of the LEX-MR GO-Gauge

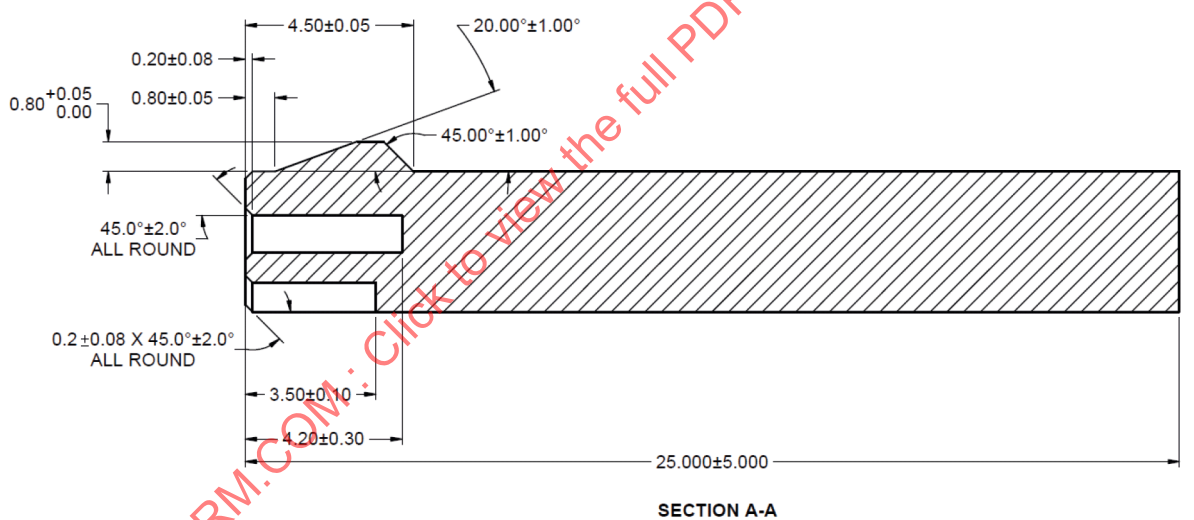


Figure 5-2 – Mechanical interface of the mating area of the LEX-MR GO-Gauge – cross section A-A

#### 5.1.2 Material of the GO-Gauge for the LEX-MR

The GO-Gauge for the LEX-MR shall be made of hardened tool steel.

## 5.2 Contact making Gauge for the LEX-LP

### 5.2.1 Mechanical drawings of the Contact making Gauge for the LEX-LP

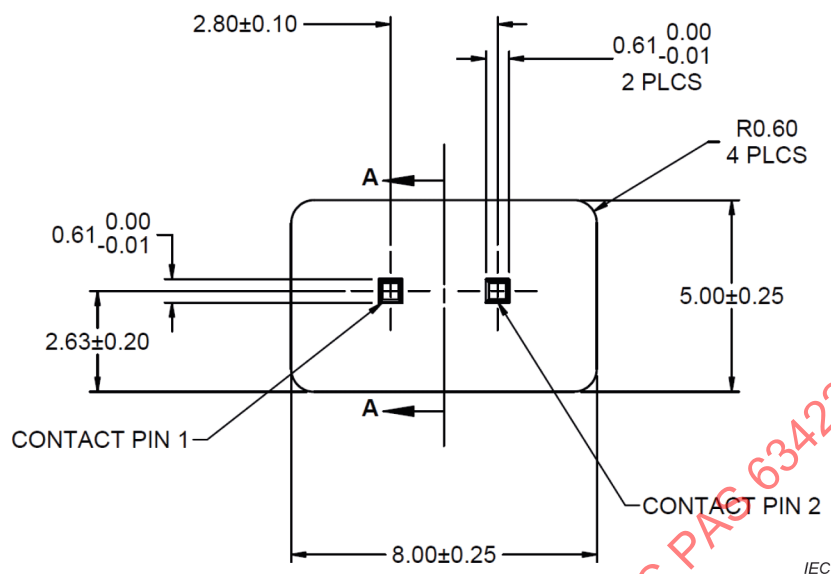


Figure 5-3 – Mechanical interface of the mating area of the LEX-LP GO-Gauge

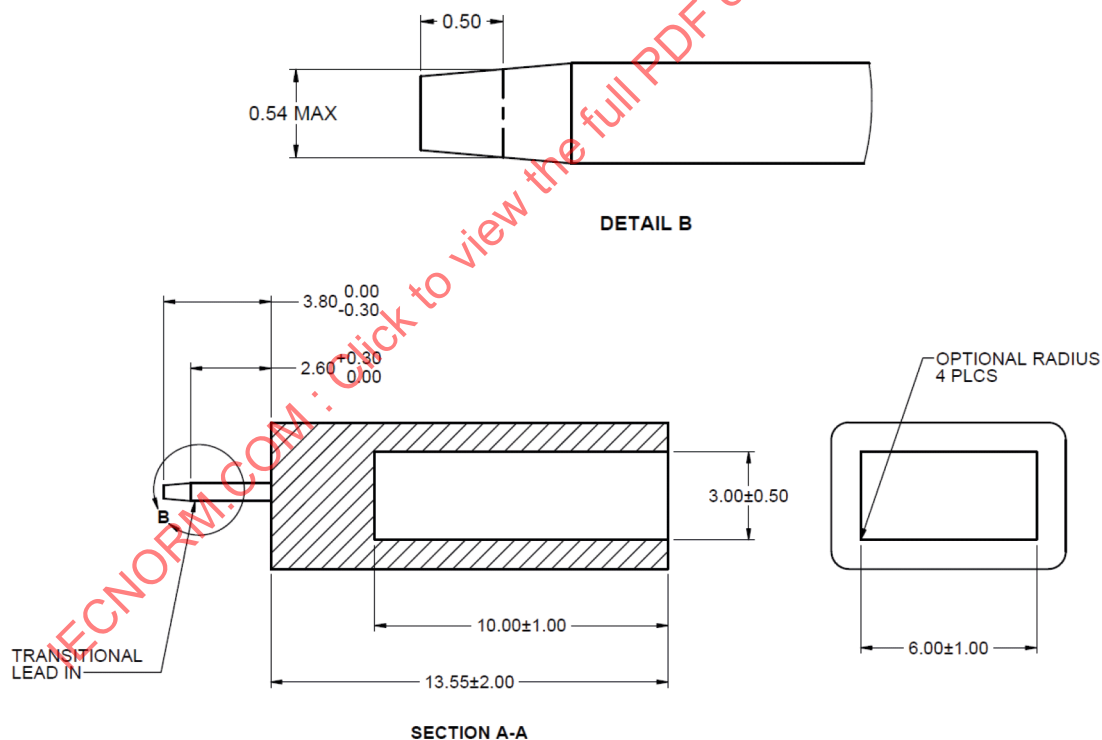


Figure 5-4 – Mechanical interface of the mating area of the LEX-LP GO-Gauge – cross section A-A

### 5.2.2 Material of the contact making Gauge for the LEX-LP

The contact making Gauge for the LEX-LP shall be made of hard copper alloy with tin over nickel plating.

The Gauge shall meet the requirements in section 7.2.3.

## 6 LEX Module Receptacle compliance tests

### 6.1 General

In order to perform the compliance tests listed below, the LEX-MR manufacturer shall provide a letter of confirmation with content and format as defined in [LoC-LEX-MR].

### 6.2 LEX Module Receptacle mechanical interface tests

#### 6.2.1 Check compliance with section 3.9.2.1 (dimensions of mating area)

The purpose of this test is to check whether the LEX-MR under test meets all requirements as listed in section 3.9.2.1.

##### 6.2.1.1 Test equipment

This test shall be conducted with measuring equipment allowing a measurement accuracy (linear and angular) equal to or better than 0.2 x tolerance.

##### 6.2.1.2 Test conditions

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

##### 6.2.1.3 Test procedure

The test procedure to be conducted depends on the label listed in column 'Verified by' in Table 6-1. In case the cell shows 'MF' the procedure is:

- The manufacturer provides the mechanical drawing of the LEX-MR under test. This drawing shall include for each dimension listed in Table 6-1 with the label 'MF', the typical value and the production tolerance.
- Check whether for all dimensions listed in Table 6-1 with the label 'MF', nominal value and production tolerances are available in the drawing provided by the manufacturer.
- Check whether for all dimensions listed in Table 6-1 with the label 'MF', the nominal value and production tolerances guarantee products within the tolerance range defined in Table 6-1.
- The manufacturer provides a report of the mechanical measurement of the LEX-MR under test.
- Check whether measurement results for all dimensions listed in Table 6-1 with the label 'MF' are available in the report provided by the manufacturer.
- Check whether for all dimensions listed in Table 6-1 with the label 'MF', the measured value is within the tolerance range.

In case the cell shows 'ATC' the procedure is:

- Measure all dimensions listed in Table 6-1 with the label 'ATC'.

**Table 6-1 – Dimension of the LEX-MR defined in Figure 3-18 and Figure 3-19**

| Dimension | Nominal | Description                    | Number of occurrences to check | Min. | Max. | Verified by |
|-----------|---------|--------------------------------|--------------------------------|------|------|-------------|
| M1        | 6.90    | Cavity length                  | 1                              | 6.85 | 6.95 | ATC         |
| M2        | 0.66    | Pin width                      | 2                              | 0.61 | 0.71 | ATC         |
| M3        | 2.80    | Pin pitch                      | 1                              | 2.70 | 2.90 | MF          |
| M4        | 0.66    | Pin height                     | 2                              | 0.61 | 0.71 | ATC         |
| M5        | 3.80    | Cavity height                  | 1                              | 3.75 | 3.85 | ATC         |
| M6        | 2.13    | Pin position                   | 2                              | 2.03 | 2.23 | MF          |
| M7        | 0.73    | Poke yoke feature height       | 1                              | 0.68 | 0.78 | ATC         |
| M8        | 2.50    | Poke yoke feature width        | 1                              | 2.45 | 2.55 | ATC         |
| M9        | 0.20    | Cavity radius                  | 4                              | -    | 0.30 | ATC         |
| N1        | -       | Pin length                     | 2                              | 2.60 | -    | MF          |
| N2        | -       | Length of transitional lead in | 2                              | -    | 3.80 | MF          |
| N3        | 3.30    | Poke yoke feature length       | 1                              | 3.20 | 3.40 | ATC         |
| N4        | 6.45    | Cavity depth                   | 1                              | 6.35 | 6.55 | ATC         |

**6.2.1.4 Pass criteria**

The LEX-MR under test passes if the measured values of all dimensions listed in Table 6-1 are within the specified tolerance range.

**6.2.2 Check compliance with section 3.9.2.2 or 3.9.2.3 (demarcation model)**

The purpose of this test is to check whether the LEX-MR under test meets the requirements of the demarcation model as defined in section 3.9.2.2 or section 3.9.2.3.

**6.2.2.1 Test equipment**

Caliper.

**6.2.2.2 Test conditions**

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

**6.2.2.3 Test procedure**

- Check whether the LEX-MR under test is applicable in a wire-to-wire system or a wire-to-board system (see section 3.9.1).
- In case the LEX-MR under test is applicable in a wire-to-wire system, check whether it does not cross the Demarcation as defined in section 3.9.2.2. Guidelines for this test are provided in [Book-1].
- In case the LEX-MR under test is applicable in a wire-to-board system, check whether it does not cross the Demarcation as defined in section 3.9.2.3. Guidelines for this test are provided in [Book-1].

**6.2.2.4 Pass criteria**

The LEX-MR under test passes if the result of the demarcation verification is positive.

**6.2.3 Test of the LEX-MR un-mating force**

The purpose of this test is to check whether after 10 mating cycles with the gauge defined in section 5.1, the force for un-mating is 5 N or more.

**6.2.3.1 Test equipment**

- Gauge defined in section 5.1.
- Force meter.

### 6.2.3.2 Test conditions

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

### 6.2.3.3 Test procedure

- Perform 10 mating/un-mating sequences with the gauge and the LEX-MR under test.
- Measure the force required to detach the gauge from the LEX-MR under test.

### 6.2.3.4 Pass criteria

The LEX-MR under test passes if the measured force is 5.0 N or more.

## 6.2.4 Test of the LEX-MR – bending of the latch-on pin housing

The purpose of this test is to check whether the latch-on pin housing of the LEX-MR does not bend up when the gauge defined in section 5.1 is fully inserted.

### 6.2.4.1 Test equipment

- Gauge defined in section 5.1.

### 6.2.4.2 Test conditions

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

### 6.2.4.3 Test procedure

- Fully insert the gauge in the LEX-MR under test.
- Inspect the latch-on pin housing.

### 6.2.4.4 Pass criteria

The LEX-MR under test passes if the latch-on pin housing of the LEX-MR does not bend up but snaps into place around the gauge.

## 6.2.5 Test of the LEX-MR contact plating

The purpose of this test is to verify that the plating to the contact areas of the LEX-MR contains the minimum proportion of tin required by this specification.

### 6.2.5.1 Test equipment

None.

### 6.2.5.2 Test conditions

None.

### 6.2.5.3 Test procedure

Inspect the letter of confirmation provided by the LEX-MR manufacturer.

### 6.2.5.4 Pass criteria

The LEX-MR under test passes if the letter of confirmation provided by the LEX-MR manufacturer indicates that the manufacturer guarantees that the plating of the contacts complies with the restrictions in Table 6-2.

**Table 6-2 – Pass criteria for percentage mass of several elements in the contact plating**

| Element                | % mass |
|------------------------|--------|
| Tin                    | ≥97.5  |
| Copper                 | ≤1.5   |
| Zinc                   | ≤0.7   |
| Total Unnamed Elements | ≤0.2   |
| Lead                   | ≤0.1   |

**6.2.6 Test of the LEX-MR contact pins**

The purpose of this test is to verify that both contact pins are coined on all 4 sides of the pins.

**6.2.6.1 Test equipment**

None.

**6.2.6.2 Test conditions**

None.

**6.2.6.3 Test procedure**

Inspect the contact pins of the LEX-MR under test.

**6.2.6.4 Pass criteria**

The LEX-MR under test passes if both contact pins are coined on all 4 sides of the pins.

**7 LEX Luminaire Plug compliance tests****7.1 General**

In order to perform the compliance tests listed below, the LEX-LP manufacturer shall provide a letter of confirmation with content and format as defined in [LoC-LEX-LP].

**7.2 LEX Luminaire Plug mechanical interface tests****7.2.1 Check compliance with section 3.9.3.1 (dimensions of mating area)**

The purpose of this test is to check whether the LEX-LP under test meets all requirements as listed in section 3.9.3.1.

**7.2.1.1 Test equipment**

This test shall be conducted with measuring equipment allowing a measurement accuracy (linear and angular) equal to or better than 0.2 x tolerance.

**7.2.1.2 Test conditions**

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

**7.2.1.3 Test procedure**

The test procedure to be conducted depends on the label listed in column 'Verified by' in Table 7-1. In case the cell shows 'MF' the procedure is:

- The manufacturer provides the mechanical drawing of the LEX-LP under test. This drawing shall include for each dimension listed in Table 7-1 with the label 'MF', the typical value and the production tolerance.
- Check whether for all dimensions listed in Table 7-1 with the label 'MF', nominal value and production tolerances are available in the drawing provided by the manufacturer.

- Check whether for all dimensions listed in Table 7-1 with the label 'MF', the nominal value and production tolerances guarantee products within the tolerance range defined in Table 7-1.
- The manufacturer provides a report of the mechanical measurement of the LEX-LP under test.
- Check whether measurement results for all dimensions listed in Table 7-1 with the label 'MF' are available in the report provided by the manufacturer.
- Check whether for all dimensions listed in Table 7-1 with the label 'MF', the measured value is within the tolerance range.

In case the cell shows 'ATC' the procedure is:

- Measure all dimensions listed in Table 7-1 with the label 'ATC'.

**Table 7-1 – Dimension of the LEX-LP defined in Figure 3-23 and Figure 3-24**

| Dimension | Nominal | Description              | Number of occurrences to check | Min. | Max. | Verified by |
|-----------|---------|--------------------------|--------------------------------|------|------|-------------|
| R1        | 2.00    | Detent element width     | 1                              | 1.95 | 2.05 | ATC         |
| R2        | 2.80    | Contact hole pitch       | 1                              | 2.70 | 2.90 | ATC         |
| R3        | 0.50    | Corner radius            | 4                              | 0.35 | -    | ATC         |
| R4        | 6.70    | Plug width               | 1                              | 6.65 | 6.75 | ATC         |
| R5        | 3.60    | Plug height              | 1                              | 3.55 | 3.65 | ATC         |
| R6        | 2.03    | Contact hole position    | 2                              | 1.93 | 2.13 | ATC         |
| R7        | -       | Poke yoke feature width  | 1                              | 2.65 | -    | ATC         |
| R8        | -       | Poke yoke feature height | 1                              | 0.78 | -    | ATC         |
| R9        | -       | Contact lead in width    | 2                              | 1.00 | -    | MF          |
| S1        | 4.50    | Detent element parameter | 1                              | 4.45 | 4.55 | MF          |
| S2        | 0.80    | Detent element parameter | 1                              | 0.75 | 0.85 | MF          |
| S3        | 20°     | Detent element parameter | 1                              | 18°  | 22°  | ATC         |
| S4        | 0.80    | Detent element parameter | 1                              | 0.80 | 0.85 | ATC         |
| S5        | 45°     | Detent element parameter | 1                              | 44°  | 46°  | ATC         |
| S6        | 45°     | Contact hole lead in     | 8                              | 40°  | 50°  | MF          |
| S7        | -       | Contact lead in height   | 2                              | 1.00 | -    | MF          |
| S8        | 45°     | Outer Chamfer            | 4                              | 40°  | 50°  | MF          |
| S9        | -       | Poke yoke feature length | 1                              | 3.40 | -    | ATC         |
| S10       | 0.20    | Outer Chamfer length     | 4                              | 0.12 | 0.28 | MF          |

#### 7.2.1.4 Pass criteria

The LEX-LP under test passes if the measured values of all dimensions listed in Table 7-1 are within the specified tolerance range.

#### 7.2.2 Check compliance with section 3.9.3.2 (demarcation model)

The purpose of this test is to check whether the LEX-LP under test meets the requirements of the demarcation model as defined in section 3.9.3.2.

##### 7.2.2.1 Test equipment

Caliper.

##### 7.2.2.2 Test conditions

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

### 7.2.2.3 Test procedure

- Check whether LEX-LP under test does not cross the Demarcation as defined in section 3.9.3.2. Guidelines for this test are provided in [Book-1].

### 7.2.2.4 Pass criteria

The LEX-LP under test passes if the result of the demarcation verification is positive.

## 7.2.3 Test of the LEX-LP contact plating

The purpose of this test is to verify that the plating to the contact areas of the LEX-LP contains the minimum proportion of tin required by this specification.

### 7.2.3.1 Test equipment

None.

### 7.2.3.2 Test conditions

None.

### 7.2.3.3 Test procedure

Inspect the letter of confirmation provided by the LEX-LP manufacturer.

### 7.2.3.4 Pass criteria

The LEX-LP under test passes if the letter of confirmation provided by the LEX-LP manufacturer indicates that the manufacturer guarantees that the plating of the contacts complies with the restrictions in Table 7-2.

**Table 7-2 – Pass criteria for percentage mass of several elements in the contact plating**

| Element                | % mass |
|------------------------|--------|
| Tin                    | ≥97.5  |
| Copper                 | ≤1.5   |
| Zinc                   | ≤0.7   |
| Total Unnamed Elements | ≤0.2   |
| Lead                   | ≤0.1   |

## 7.3 LEX Luminaire Plug electrical interface tests

### 7.3.1 Test contact resistance

The purpose of this test is to check whether the contact resistance of the LEX-LP under test meets the requirements in section 4.5.

#### 7.3.1.1 Test equipment

- Gauge defined in section 5.2.

#### 7.3.1.2 Test conditions

None.

#### 7.3.1.3 Test procedure

Fully insert the LEX-LP under test in the gauge and measure the resistance between the gauge and each of the two contacts of the LEX-LP.

#### 7.3.1.4 Pass criteria

The LEX-LP under test passes if both measured resistance values are less than 500mΩ.

## 8 LEX-M compliance tests

### 8.1 General

In order to perform the compliance tests listed below, the LEX-M manufacturer shall provide an instruction on how to mount the LEX-M to a Luminaire and a letter of confirmation with content and format as defined in [LoC-LEX-M].

### 8.2 LEX-M mechanical interface tests

#### 8.2.1 Test of the LEX-M demarcation

The purpose of this test is to verify that the LEX-M under test is compliant with the applicable demarcation model as defined in section 3.

##### 8.2.1.1 Test equipment

Caliper.

##### 8.2.1.2 Test conditions

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

##### 8.2.1.3 Test procedure

- Determine the category of the LEX-M under test from its Product Data Set.
- Find the corresponding LEX-M Demarcation model in section 3.
- Verify that the total set of LEX-M under test + (optional) wire to LEX-MR + LEX-MR + maximum LEX-LP (as defined in section 3.9.3.2) is within the keep-in volume of the LEX-M Demarcation model. Additional guidelines for this test are provided in [Book 1] – Annex B.

##### 8.2.1.4 Pass criteria

The LEX-M under test passes if the total set of LEX-M under test + (optional) wire to LEX-MR + LEX-MR + maximum LEX-LP (as defined in section 3.9.3.2) is within the keep-in volume of the Demarcation model.

#### 8.2.2 Test of the LEX-M fixation, detachment and dependency on mounting plate thickness

The purpose of this test is to verify that the means of fixation implemented in the LEX-M under test is such that:

- The fixation does not depend on specific features in the Luminaire other than the LEX-S as defined in section 3.5.3.3.
- The LEX-M can be detached from the Luminaire without damaging the LEX-M nor the Luminaire.
- Fixation works for all thicknesses of the mounting plate within the allowed range as defined in section 3.5.3.3.

##### 8.2.2.1 Test equipment

- Aluminum mounting plate with a LEX-S in the same category as the LEX-M under test, with minimum dimensions and a thickness equal to the minimum thickness as defined in section 3.5.3.3.
- Aluminum mounting plate with a LEX-S in the same category as the LEX-M under test, with minimum dimensions and a thickness equal to the maximum thickness as defined in section 3.5.3.3.

##### 8.2.2.2 Test conditions

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

##### 8.2.2.3 Test procedure

- Mount the LEX-M under test to the mounting plate with minimum thickness and verify that the fixation is proper.

- Detach the LEX-M under test from the mounting plate and verify that the LEX-M can be detached from the mounting plate without damaging the LEX-M nor the mounting plate.
- Mount the LEX-M under test to the mounting plate with maximum thickness and verify that the fixation is proper.
- Detach the LEX-M under test from the mounting plate and verify that the LEX-M can be detached from the mounting plate without damaging the LEX-M nor the mounting plate.

#### **8.2.2.4 Pass criteria**

The LEX-M under test passes if:

- mounting the LEX-M under test to a mounting plate with minimum thickness as well as to a mounting plate with maximum thickness results in a proper fixation.
- the LEX-M can be detached from the mounting plate with minimum thickness as well as from a mounting plate with maximum thickness without damaging the LEX-M nor the mounting plate.

#### **8.2.3 Test of the LEX-MR of the LEX-M under test**

The purpose of this test is to verify the mechanical interface of the LEX-MR of the LEX-M under test. This compliance test is not required in case the LEX-M under test features a Zhaga certified LEX-MR.

In case the LEX-M under test does not feature a Zhaga certified LEX-MR, all tests in section 6 shall be conducted.

### **8.3 LEX-M electrical interface tests**

#### **8.3.1 General**

In order to perform the compliance tests listed below, the LEX-M manufacturer shall provide a letter of confirmation with content and format as defined in [LoC-LEX-M].

#### **8.3.2 Test of the LEX-M pin assignment**

The purpose of this test is to verify whether pin assignment of the LEX-M complies with Table 4-1.

##### **8.3.2.1 Test equipment**

None.

##### **8.3.2.2 Test conditions**

None.

##### **8.3.2.3 Test procedure**

Inspect the letter of confirmation provided by the LEX-M manufacturer.

##### **8.3.2.4 Pass criteria**

The LEX-M under test passes if the letter of confirmation provided by the LEX-M manufacturer indicates that:

- Pin 1 is used for DA- (Negative pole for the DALI communication and bus power) and not used for other purposes.
- Pin 2 is used for DA+ (Positive pole for the DALI communication and bus power) and not used for other purposes.

#### **8.3.3 Test of the LEX-M DALI communication & DALI bus power requirements**

The purpose of this test is to verify whether the LEX-M meets the DALI communication & DALI bus power requirements as listed in section 4.7.2.

##### **8.3.3.1 Test equipment**

None.

### 8.3.3.2 Test conditions

None.

### 8.3.3.3 Test procedure

- Check whether the LEX-M under test is listed in [DiiA Database] and whether this listing indicates that the LEX-M is compliant with [DALI – Part 351] (*Luminaire mounted control devices*).
- Check letter of confirmation provided by the LEX-M manufacturer.

### 8.3.3.4 Pass criteria

The LEX-M under test passes if

- the LEX-M meets the condition listed in section 8.3.3.3 and
- the letter of confirmation provided by the LEX-M manufacturer indicates that the LEX-M is a Type C control device, or a bus powered Type D control device as defined in [DALI – Part 351] (*Luminaire mounted control devices*).

## 9 Luminaire compliance tests

### 9.1 General

In order to perform the compliance tests listed below, the Luminaire manufacturer shall provide a circuit diagram and a letter of confirmation with content and format as defined in [LoC-Luminaire].

### 9.2 Luminaire mechanical interface tests

In case the Luminaire under test holds multiple independent LEX-Bs, each section of the Luminaire containing a single LEX-B shall pass the tests as defined in sections 9.3.1, 9.3.2, 9.3.3 and 9.3.4.

#### 9.2.1 Test of the number of LEX-Ss

The purpose of this test is to verify that the Luminaire under test features at least one LEX-S.

##### 9.2.1.1 Test equipment

None.

##### 9.2.1.2 Test conditions

None.

##### 9.2.1.3 Test procedure

Inspect the Luminaire under test and count the number of LEX-Ss.

##### 9.2.1.4 Pass criteria

The Luminaire under test passes if it features at least one LEX-S.

#### 9.2.2 Test of the number of LEX-LPs

The purpose of this test is to verify that the Luminaire under test features exactly one LEX-LP.

##### 9.2.2.1 Test equipment

None.

##### 9.2.2.2 Test conditions

None.

##### 9.2.2.3 Test procedure

Inspect the Luminaire under test and count the number of LEX-LPs.

### 9.2.2.4 Pass criteria

The Luminaire under test passes if it features exactly one LEX-LP.

### 9.2.3 Test of the LEX-S

The purpose of this test is to verify that the LEX-S of the Luminaire under test is compliant with the applicable mechanical specifications as defined in section 3.

#### 9.2.3.1 Test equipment

This test shall be conducted with measuring equipment allowing a measurement accuracy (linear and angular) equal to or better than 0.2 x tolerance.

#### 9.2.3.2 Test conditions

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

#### 9.2.3.3 Test procedure

- Determine the category of the Luminaire under test from its Product Data Set.
- In case the category of the Luminaire under test is R44x17, measure all dimensions listed in Table 9-1.

**Table 9-1 – Dimensions of the LEX-S for category R44x17 defined in Figure 3-4 and Figure 3-5**

| Dimension | Nominal | Description          | Number of occurrences to check | Min. | Max. |
|-----------|---------|----------------------|--------------------------------|------|------|
| B1        | 17.2    | LEX-S width          | 1                              | 17.1 | 17.3 |
| B2        | 44.2    | LEX-S length         | 1                              | 44.1 | 44.3 |
| B3        | 2.3     | Curvature of corners | 4                              | 2.2  | 2.4  |
| C1        | -       | Border length        | 1                              | 61   | -    |
| C2        | -       | Border width         | 1                              | 23   | -    |

- In case the category of the Luminaire under test is R60x22, measure all dimensions listed in Table 9-2.

**Table 9-2 – Dimensions of the LEX-S for category R60x22 defined in Figure 3-7 and Figure 3-8**

| Dimension | Nominal | Description          | Number of occurrences to check | Min. | Max. |
|-----------|---------|----------------------|--------------------------------|------|------|
| E1        | 22.0    | LEX-S width          | 1                              | 21.8 | 22.2 |
| E2        | 60.0    | LEX-S length         | 1                              | 59.8 | 60.2 |
| E3        | -       | Curvature of corners | 4                              | -    | 0.5  |
| F1        | -       | Border length        | 1                              | 69   | -    |
| F2        | -       | Border width         | 1                              | 28   | -    |

- In case the category of the Luminaire under test is C22-T1, measure all dimensions listed in Table 9-3.

**Table 9-3 – Dimensions of the LEX-S for category C22-T1 defined in Figure 3-10 and Figure 3-11**

| Dimension | Nominal | Description     | Number of occurrences to check | Min.  | Max.  |
|-----------|---------|-----------------|--------------------------------|-------|-------|
| H1        | 22.23   | LEX-S diameter  | 1                              | 21.82 | 23.01 |
| J1        | -       | Border diameter | 1                              | 36.0  | -     |

- In case the category of the Luminaire under test is C22-T2, measure all dimensions listed in Table 9-4.

**Table 9-4 – Dimensions of the LEX-S for cat. C22-T2 defined in Figure 3-13, Figure 3-14 and Figure 3-15**

| Dimension | Nominal | Description               | Number of occurrences to check | Min.  | Max.  |
|-----------|---------|---------------------------|--------------------------------|-------|-------|
| H1        | 22.23   | LEX-S diameter            | 1                              | 21.82 | 23.01 |
| J1        | -       | Border diameter           | 1                              | 36.0  | -     |
| L1        | -       | Internal border width     | 1                              | 36.0  | -     |
| L2        | -       | Internal border length I  | 1                              | 35.5  | -     |
| L3        | -       | Internal border length II | 1                              | 60.5  | -     |

#### 9.2.3.4 Pass criteria

The Luminaire under test passes if the measured values of all dimensions listed in the appropriate table are within the specified range.

#### 9.2.4 Test of the Luminaire demarcation

The purpose of this test is to verify that the Luminaire under test is compliant with the applicable demarcation model as defined in section 3.

##### 9.2.4.1 Test equipment

Caliper.

##### 9.2.4.2 Test conditions

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

##### 9.2.4.3 Test procedure

- Determine the category of the Luminaire under test from its Product Data Set.
- Find the corresponding LEX-M Demarcation model in section 3.
- Verify that the Luminaire provides the keep-out volume of the LEX-M Demarcation model. Additional guidelines for this test are provided in [Book 1] – Annex B.

##### 9.2.4.4 Pass criteria

The Luminaire under test passes if the Luminaire provides the keep-out volume of the LEX-M Demarcation model.

#### 9.2.5 Test of the LEX-LP of the Luminaire under test

The purpose of this test is to verify the mechanical interface of the LEX-LP of the Luminaire under test. This compliance test is not required in case the Luminaire under test features a Zhaga certified LEX-LP.

In case the Luminaire under test does not feature a Zhaga certified LEX-LP, all tests in section 7.2 shall be conducted.

### 9.2.6 Test of the thickness of the mounting plate

The purpose of this test is to verify that the thickness of the mounting plate of the Luminaire under test is in the range  $0.4 \leq D \leq 1.5$  mm.

#### 9.2.6.1 Test equipment

Caliper.

#### 9.2.6.2 Test conditions

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

#### 9.2.6.3 Test procedure

Measure the thickness of the mounting plate in the region of the LEX-S border as defined in section 3.

#### 9.2.6.4 Pass criteria

The Luminaire under test passes if the thickness of its mounting plate is in the range  $0.4 \leq D \leq 1.5$  mm.

### 9.3 Luminaire electrical interface tests

In case the Luminaire under test holds multiple independent LEX-Bs, each section of the Luminaire containing a single LEX-B shall pass the tests as defined in sections 9.3.1, 9.3.2, 9.3.3 and 9.3.4.

#### 9.3.1 Test compliance with [D4i Requirements]

The purpose of this test is to verify that the Luminaire meets all requirements for Luminaires as defined in section 7 of [D4i Requirements].

##### 9.3.1.1 Test equipment

None.

##### 9.3.1.2 Test conditions

None.

##### 9.3.1.3 Test procedure

Inspect the letter of confirmation provided by the Luminaire manufacturer.

##### 9.3.1.4 Pass criteria

The Luminaire under test passes if the letter of confirmation provided by the Luminaire manufacturer indicates that the Luminaire meets all requirements for Luminaires as defined in section 7 of [D4i Requirements].

#### 9.3.2 Test of the Luminaire pin assignment

The purpose of this test is to verify whether the pin assignment of the LEX-LP of the Luminaire under test complies with Table 4-1.

##### 9.3.2.1 Test equipment

None.

##### 9.3.2.2 Test conditions

None.

##### 9.3.2.3 Test procedure

Inspect the circuit diagram of the Luminaire under test and check whether for the LEX-LP the following conditions are met:

- Pin 1 is connected to the LEX-B line for DA- (Negative pole for the DALI communication and bus power) and not used for other purposes.

- Pin 2 is connected to the LEX-B line for DA+ (Positive pole for the DALI communication and bus power) and not used for other purposes.

#### **9.3.2.4 Pass criteria**

The Luminaire under test passes if all conditions listed in section 9.3.2.3 are met.

### **9.3.3 Test of the Luminaire electrical insulation**

The purpose of this test is to verify whether the Luminaire complies at its LEX-LP with the requirements on electrical insulation as listed in section 4.6.1.

#### **9.3.3.1 Test equipment**

None.

#### **9.3.3.2 Test conditions**

None.

#### **9.3.3.3 Test procedure**

Inspect the letter of confirmation provided by the Luminaire manufacturer.

#### **9.3.3.4 Pass criteria**

The Luminaire under test passes if the letter of confirmation provided by the Luminaire manufacturer indicates that all contacts of each LEX-LP of the Luminaire under test are insulated versus mains power according to the requirements for basic insulation as defined in IEC 60598-1.

### **9.3.4 Test of the Luminaire DALI communication & DALI bus power requirements**

The purpose of this test is to verify whether the Luminaire meets the DALI communication & DALI bus power requirements as listed in section 4.7.1.

#### **9.3.4.1 Test equipment**

None.

#### **9.3.4.2 Test conditions**

None.

#### **9.3.4.3 Test procedure**

- Inspect the circuit diagram of the Luminaire under test and check whether the following conditions are met:
  - All non-emergency ECGs are installed in the Luminaire under test and are connected to the LEX-B.
  - The Luminaire under test does not feature provisions for connection to an external DALI bus.
  - The (optional) bus power supply unit is installed in the Luminaire and is connected to the LEX-B.
- Inspect the letter of confirmation provided by the Luminaire manufacturer.

#### **9.3.4.4 Pass criteria**

The Luminaire under test passes if:

- all conditions as listed in section 9.3.4.3 are met and
- the letter of confirmation provided by the Luminaire manufacturer indicates that the Luminaire under test does not contain a DALI application controller nor DALI input devices as defined in [DALI – Part 103].

## 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 20 are listed.

#### **A.1 LEX-M Product Data Set**

The LEX-M Product Data Sets shall contain the following information:

- The mechanical category (R44x17, R60x22, C22-T1, C22-T2).

#### **A.2 Luminaire Product Data Set**

The LEX-M Product Data Sets shall contain the following information:

- The mechanical category (R44x17, R60x22, C22-T1, C22-T2), for each LEX-S.

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## Section 2

### Zhaga Interface Specification Book 1

#### Overview and Common Information

##### Summary (informative)

##### Background

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

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

##### Contents

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

##### Intended Use

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

## 1 General

### 1.1 Introduction

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

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

### 1.2 Scope

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

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

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

### 1.3 Conformance and references

#### 1.3.1 Conformance

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

#### 1.3.2 Normative references

|                     |                                                                                                                                             |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| [ANSI C78.377]      | American National Standard for electric lamps—Specifications for the Chromaticity of Solid State Lighting Products, ANSI NEMA ANSLG C78.377 |
| [CIE 13.3]          | Method of measuring and specifying colour rendering properties of light sources, CIE 13.3                                                   |
| [IEC TR 61341:2010] | Method of measurement of centre beam intensity and beam angle(s) of reflector lamps                                                         |
| [IEC TR 62732]      | Three-digit code for designation of colour rendering and correlated colour temperature                                                      |
| [IES LM-79-08]      | IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products, IES LM-79-08                          |
| [NIST TN 1297]      | NIST Technical Note 1297; 1994 Edition—Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results                 |

|              |                                                                                                    |
|--------------|----------------------------------------------------------------------------------------------------|
| [Zhaga-ECG]  | Zhaga Interface Specification, Book 13 Separate Electronic Control Gear                            |
| [LEDset-Inf] | LEDset1 Information Interface Specification, Edition 1.2, November, 2016 available from md-sig.org |
| [LEDset-Pow] | LEDset Power Interface Specification, Edition 1.1, November, 2016 available from md-sig.org        |

### 1.3.3 Informative references

|              |                                        |
|--------------|----------------------------------------|
| [Zhaga LTLA] | Zhaga Logo Trademark License Agreement |
|--------------|----------------------------------------|

## 1.4 Common definitions<sup>1</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.                                                                                                                                                                                                                                                                                                                   |
| 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.                                                                                                                                                                                                                                                                                                                                                                       |

<sup>1</sup> The definitions are possibly further restricted in the other Zhaga Books.

|                                |                                                                                                                                                                                                                                                                                                                                                             |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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 380 nm up to 780 nm (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.

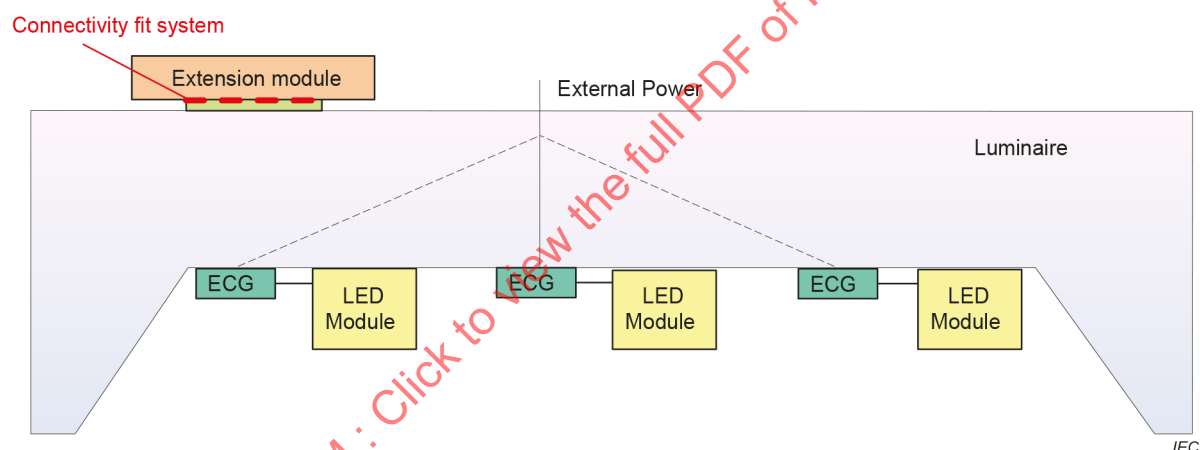


**Figure 2-1 – Schematic overview of a Luminaire and one or more non-integrated LED Light Engines**

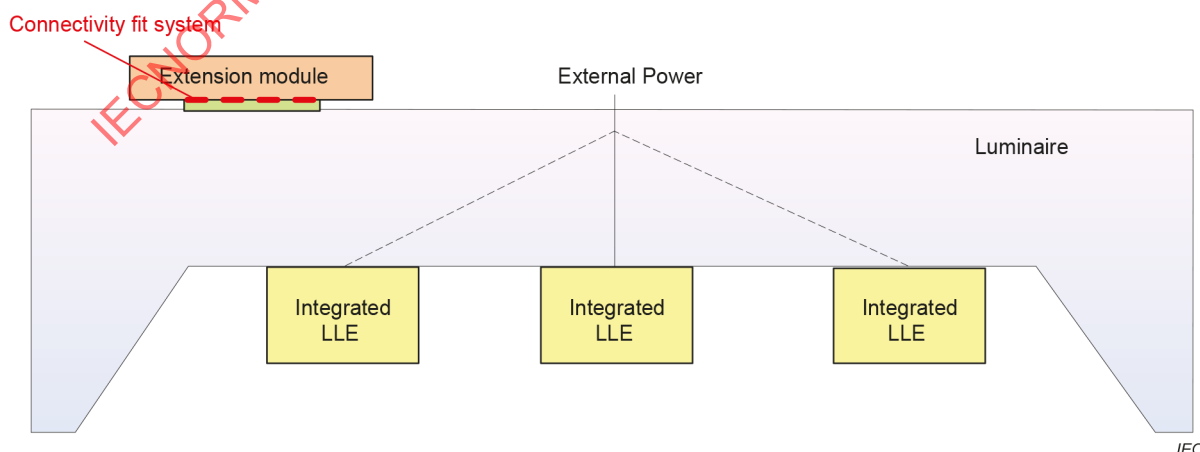


**Figure 2-2 – Schematic overview of a Luminaire and one or more integrated LED Light Engines**

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.

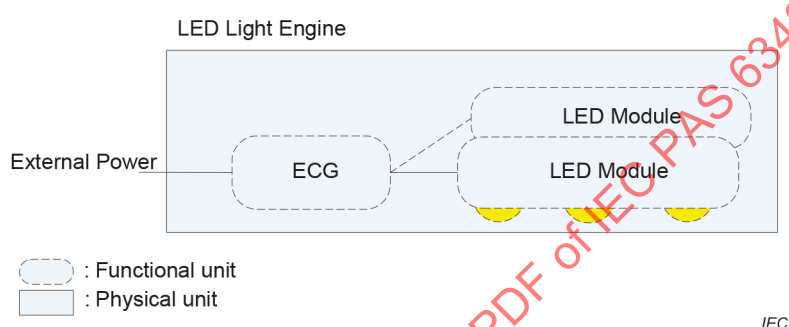


**Figure 2-3 – Schematic overview of a LED Light Engine with Integrated ECG**

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.

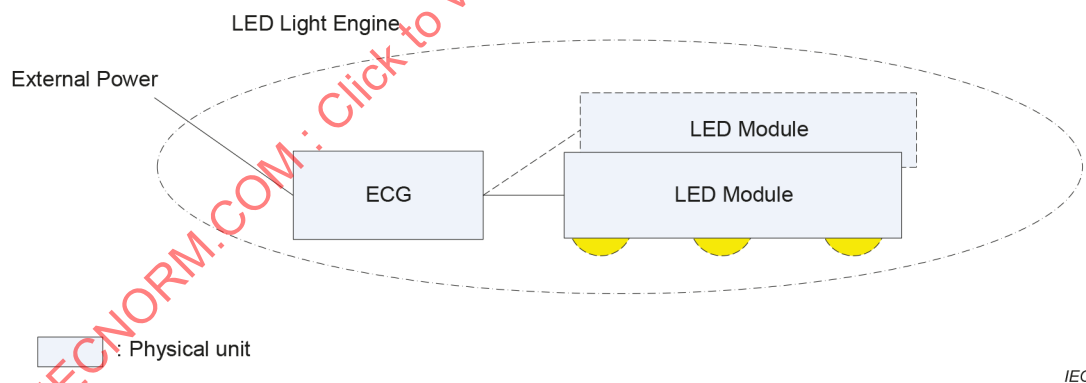


**Figure 2-4 – Schematic overview of a LED Light Engine with Separate ECG**

### 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.

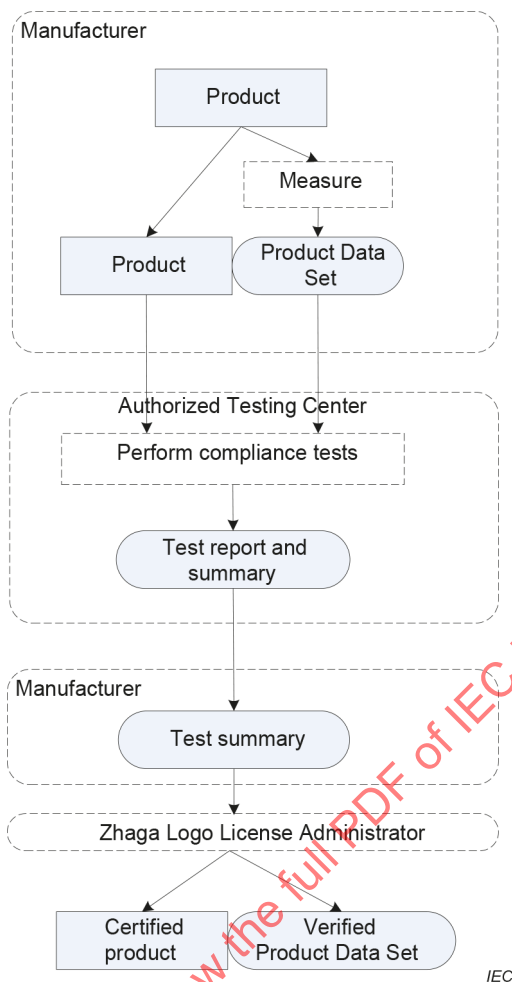


**Figure 2-5 – Overview of test and certification of Zhaga products**

### 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.

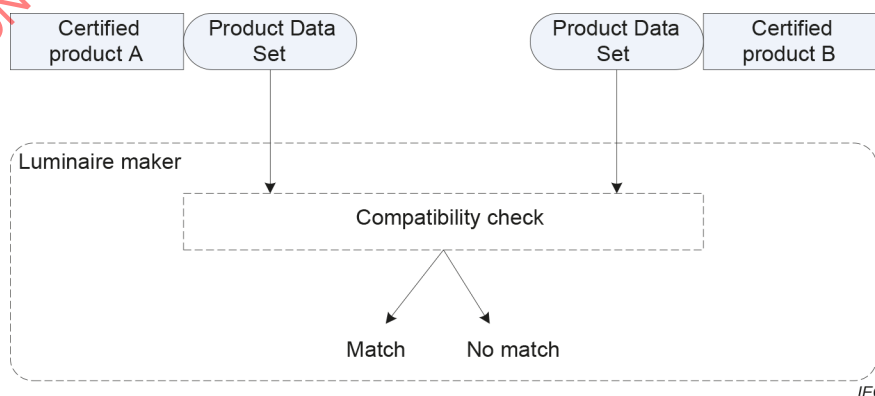


**Figure 2-6 – Compatibility check**

## 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

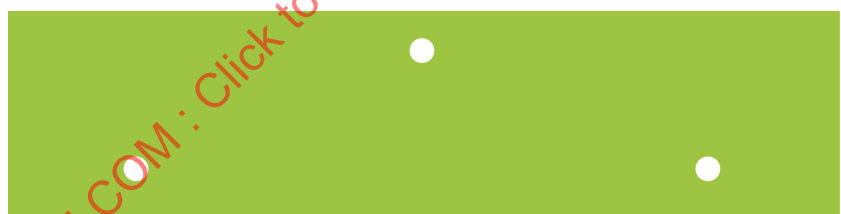
The mechanical interface between the Separate ECG and the Luminaire is defined in [Zhaga-ECG].

### 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.



IEC

**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.

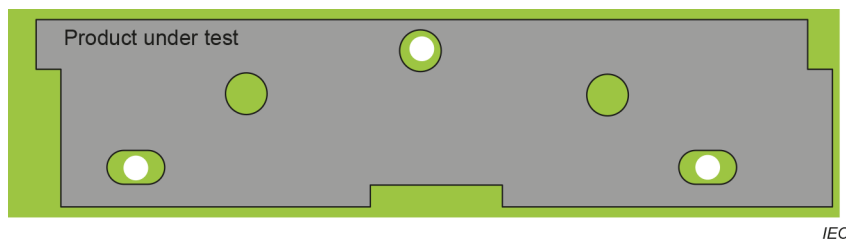


**Figure 3-2 – Example of a product which is compliant with the Demarcation Model**

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

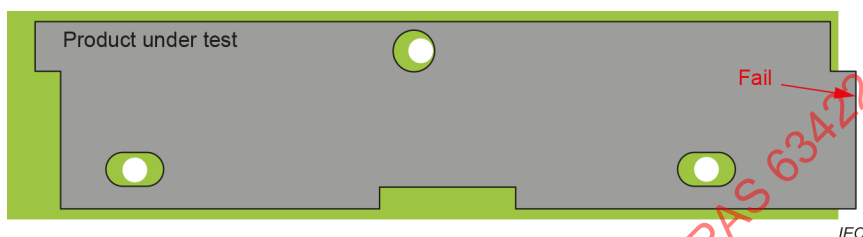


**Figure 3-3 – Example of a product which is not compliant with the Demarcation Model**

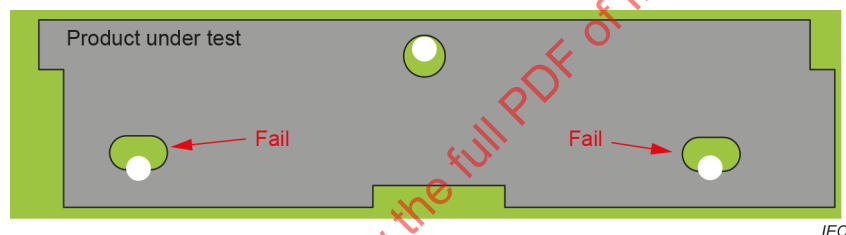


**Figure 3-4 – Example of a product which is not compliant with the Demarcation Model**

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>2</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.

<sup>2</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.

- 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.

**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

In the operating conditions as defined in the corresponding book, the LLE, LED Module or LED Array shall produce a luminous flux equal to the Rated luminous flux specified in the PDS. In case of an LLE with multiple LED Modules, luminous flux is defined per LED Module.

#### 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.

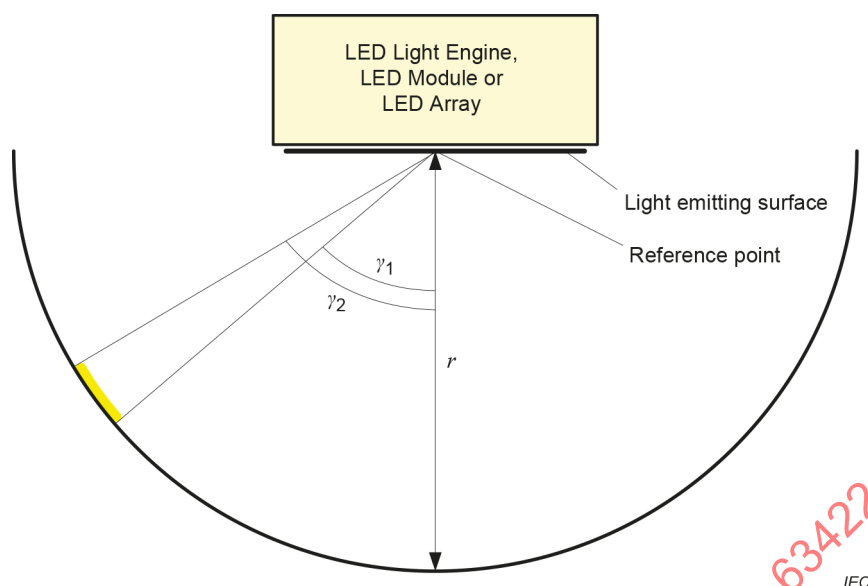


**Figure 4-1 – Rotationally symmetric solid angle bounded by the polar angles  $\gamma_1$  and  $\gamma_2$  which is used to define the Relative Partial Luminous Flux**

#### 4.4.1 Beam angle and beam angle categories

The beam angle shall be defined as in [IEC61341:2010] and the beam angle categories shall be defined as in Table 4-3.

**Table 4-3 – Definition of beam angle categories**

| Beam angle category | Minimum beam angle<br>( $^{\circ}$ ) | Maximum beam angle<br>( $^{\circ}$ ) |
|---------------------|--------------------------------------|--------------------------------------|
| 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 CCT 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 of 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.

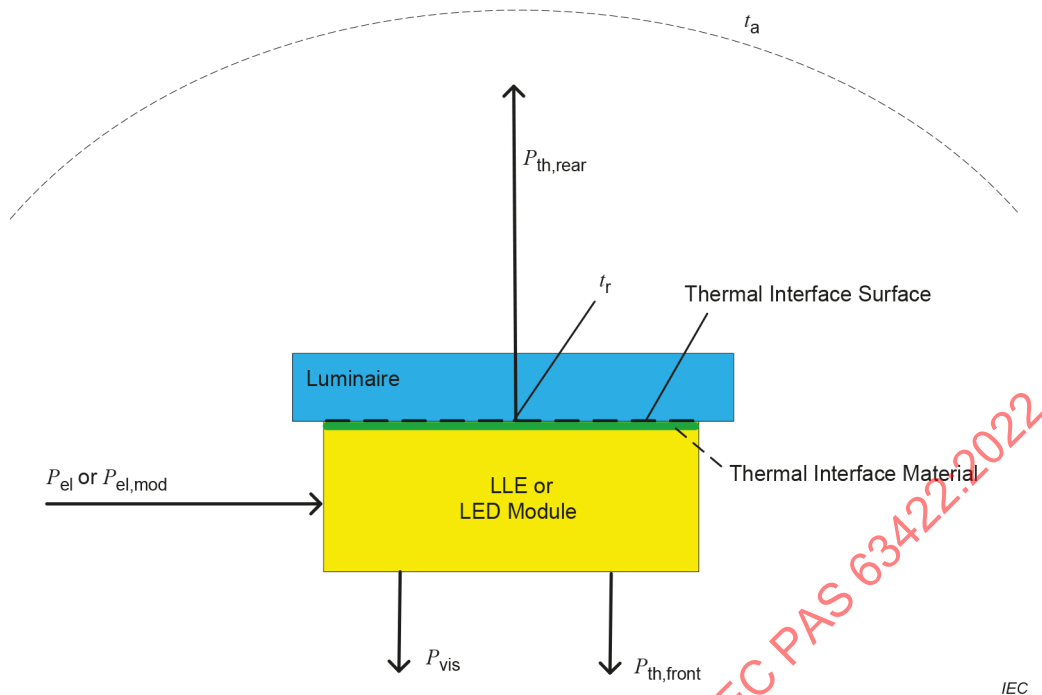


**Figure 6-1 – Thermal model of a LLE – Luminaire or a LED Module – Luminaire combination**

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:

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

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

Here,  $P_{vis}$  is defined as the radiant flux in the visible light spectrum ( $380 \text{ nm} < \lambda < 780 \text{ nm}$ )<sup>3</sup>.

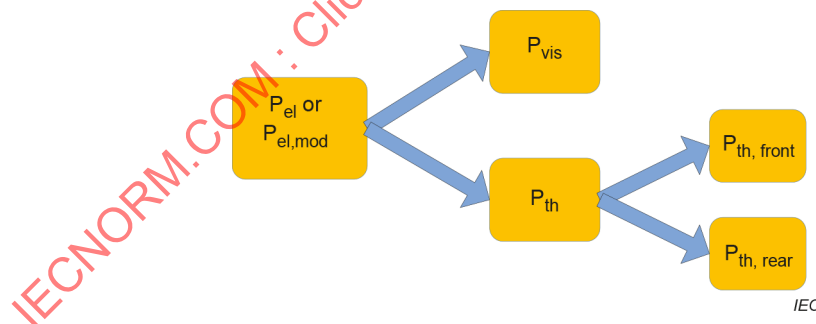


**Figure 6-2 – Power conversion**

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>4</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>5</sup>. This portion is denoted by  $P_{th,rear}$ .

<sup>3</sup> IR radiation is not included in  $P_{vis}$  and it is assumed that radiation in the range  $\lambda < 380 \text{ nm}$  is negligible.

<sup>4</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>5</sup> Heat transfer via conduction through other parts of the system is assumed to be negligible.

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

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>6</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:

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

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

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

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

## 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).*

<sup>6</sup> "steady state" is defined in section A.1.3.5.

### 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>7</sup>. For such systems, the thermal resistance of the Luminaire is defined as:

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

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.

<sup>7</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.

In order to determine whether a particular LLE or LED Module is thermally compatible<sup>8</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:

|                                        |    |     |     |     |                                        |    |     |     |     |
|----------------------------------------|----|-----|-----|-----|----------------------------------------|----|-----|-----|-----|
| <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.

<sup>8</sup> "thermally compatible" means that the LLE-Luminaire or LED Module/LED Array-Luminaire combination will operate at  $t_r \leq t_{r,max}$ .

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:

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

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

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

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.

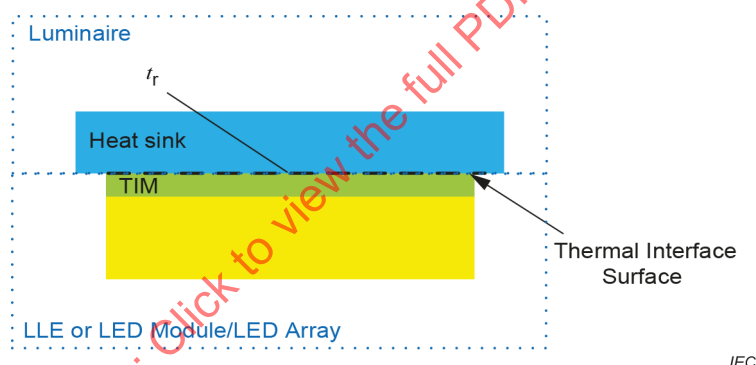


**Figure 6-3 – Position of the Thermal Interface Surface in case of a configuration with TIM**

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 ( $P_{\text{vis}}$ ) 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.*