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PUBLICLY AVAILABLE SPECIFICATION

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Zhaga Interface Specification Book 18 including Book 1 – Outdoor Luminaire Extension Interface

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IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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INTERNATIONAL
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ZHAGA INTERFACE SPECIFICATION BOOK 18 INCLUDING BOOK 1 – OUTDOOR LUMINAIRE EXTENSION INTERFACE

FOREWORD

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IEC PAS 63421 has been processed by IEC technical committee 34: Lighting.

The text of this PAS is based on the following document:

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

Draft PAS	Report on voting
34/890/DPAS	34/900/RVDPAS

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INTRODUCTION

This PAS is a reproduction of Zhaga Book 1 Edition 1.9 and Book 18 Edition 2.0 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 18 Edition 2.0 – Outdoor Luminaire Extension Interface.

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

Zhaga Book 1 is essential to the interpretation of Zhaga Book 18 (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.

Section 1

Zhaga Interface Specification Book 18

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

This Book 18 defines a standardized interface between a LED Luminaire and a sensing/communication module (Luminaire Extension Module, LEX-M) that can be attached to the Luminaire. The interface is intended to be used in outdoor applications with high IP rating. The LEX-M may provide for example sensory inputs to the Luminaire or communication between the Luminaire and a network.

This Book should be read together with Zhaga Book 1.

Intended Use

The Luminaire Extension Module, Luminaire Extension Cap and Luminaire Extension Receptacle defined in this Book 18 are intended to be installed and replaced by professionals only.

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

This Book 18 defines a standardized interface between a LED Luminaire and a sensing/communication module (Luminaire Extension Module, LEX-M) that can be attached to the Luminaire. The interface is intended to be used in outdoor applications with high IP rating. The LEX-M may provide for example sensory inputs to the Luminaire or communication between the Luminaire and a network.

For attaching the LEX-M to the Luminaire, the Luminaire features one or two Luminaire Extension Receptacles (LEX-R) and the LEX-M features a base plate. Figure 1-1 shows an informative 3D-drawing of the LEX-R and the LEX-M base plate.

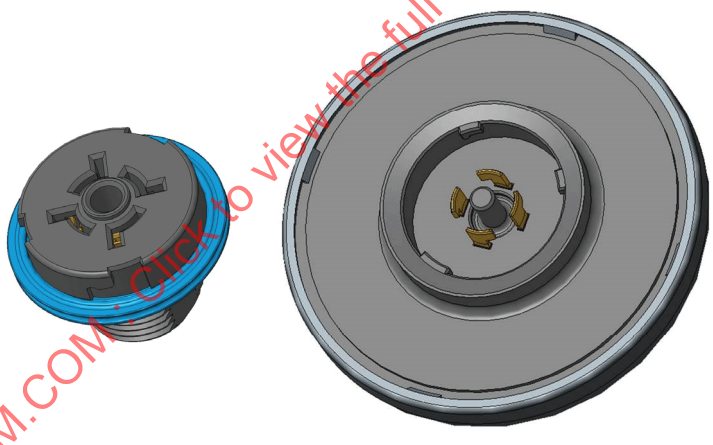


Figure 1-1 – 3D-drawings of the Luminaire Extension Receptacle (top view) and the Luminaire Extension Module base plate (bottom view) as defined in this Book 18 (Informative)

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 150]	DiiA specification – DALI Part 150 – AUX Power Supply – Version 1.1 – October 2019.
[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]	https://www.digitalilluminationinterface.org/products
[LoC-Luminaire]	Template for Letter of confirmation for Book-18 Luminaires, published on the Zhaga website.
[LoC-LEX-M]	Template for Letter of confirmation for Book-18 LEX-Ms, published on the Zhaga website.
[IEC 60598-1]	IEC 60598-1, Luminaires – Part 1: General requirements and tests.

1.4 Definitions

This section defines terms that have a specific meaning in the context of this Book 18. Terms that have a specific meaning across all Zhaga Books are defined in [Book 1].

Luminaire Extension Module	Module according to the specifications in this book.
Luminaire Extension Module Base Plate	Base plate of the Luminaire Extension Module according to the specifications in this book.
Luminaire Extension Receptacle	Receptacle according to the specifications in this book.
Luminaire Extension Cap	Cap 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 18. Acronyms that have a specific meaning across all Zhaga Books are defined in [Book 1].

LEX-M	Luminaire Extension Module
LEX-R	Luminaire Extension Receptacle
LEX-C	Luminaire Extension Cap
LEX-B	Luminaire Extension Bus
PSU	Power Supply Unit

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 18 are capitalized.

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

2.2 Description of the LEX-M, LEX-M base plate, LEX-C and LEX-R

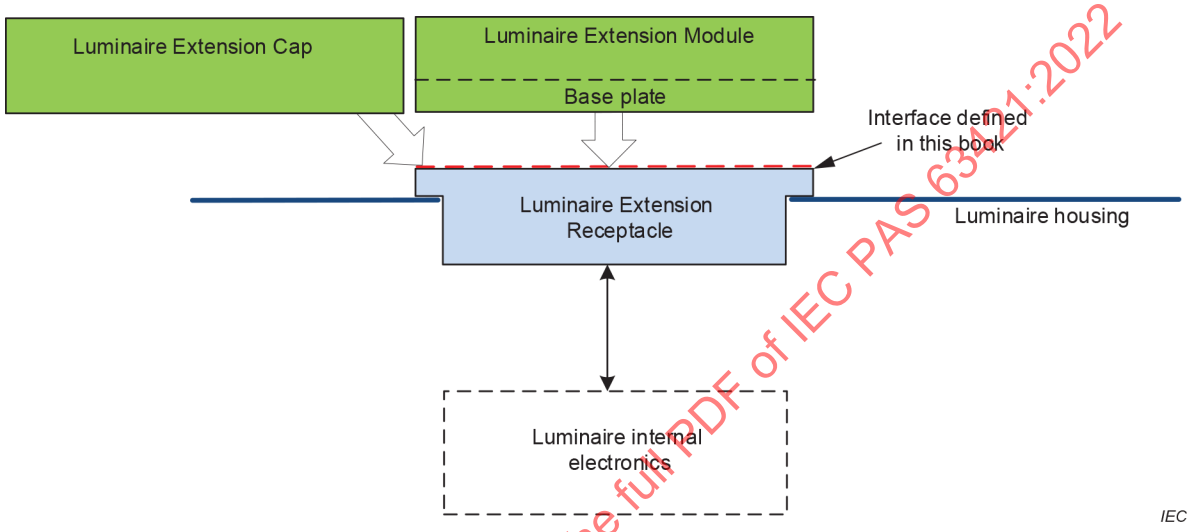


Figure 2-1 – Luminaire Extension Module, Cap and Receptacle in a system

Figure 2-1 gives an overview of a Luminaire with Luminaire Extension Receptacle, a Luminaire Extension Cap and a Luminaire Extension Module with a base plate. The Luminaire Extension Receptacle is mounted at the exterior of the Luminaire and the contacts of this receptacle are typically connected to the Luminaire internal electronics.

The Luminaire Extension Module is a separate unit which can easily be attached to the Luminaire Extension Receptacle by means of a twist-lock. Typically, it holds additional functionality to enrich the functionality of the total system.

The LEX-M base plate is intended to be integrated in a LEX-M and provides all features for mating with the LEX-R. The LEX-M base plate can be independently Zhaga certified.

The Luminaire Extension Cap is a separate unit which can also easily be attached to the Luminaire Extension Receptacle by means of a twist-lock. It does not hold any functionality and is used to cover the receptacle in case no LEX-M is used.

The specifications in this Book 18 guarantee Plug-and-Play when one or two LEX-Ms are mounted to the Luminaire according to the requirements given in section 4. 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-Ms. It does not guarantee performance (e.g. sensitivity of a motion detector).

The specification of this Book 18 defines the following elements:

- The mechanical interface between the LEX-R and the LEX-M base plate.
- The mechanical interface between the LEX-R and the LEX-C.
- The keep-in area of the LEX-M.
- The keep-out area of the luminaire to allow mounting of the LEX-M or LEX-C.

- The electrical and communication interface between the Luminaire's LEX-R(s) and one or two LEX-Ms.

2.3 Outline of this Book

This Book 18 consists of two parts:

Part 1, Interface Definition, defines the LEX-M(C)/LEX-R interface in terms of the two sub interfaces:

- The mechanical interface (section 3).
- The electrical & communication interface (section 4).

Part 2, Compliance Tests[1], defines:

- Specific tools, which are used for testing compliance of a LEX-M, a base plate, a LEX-C or a LEX-R (section 5).
- The Luminaire Extension Module base plate compliance tests (section 6).
- The Luminaire Extension Cap compliance tests (section 7).
- The Luminaire Extension Receptacle compliance tests (section 8).
- The Luminaire Extension Module compliance tests (section 9).
- The Luminaire compliance tests (section 10).

The Annexes to this Book 18 provide the following additional information:

- Application guidelines (Annex A)
- Mechanical drawings of the gauges (Annex B, Annex C and Annex D)
- Descriptions of the mechanical interface tests (Annex E)
- History of changes (Annex F)

[1] When a ATC is requested to check compliance of a specific product with book-18, the ATC determines the type of product (e.g. LEX-M base plate), locates the corresponding section in part 2 of the document (in this example section 6) and executes all compliance test listed in this section.

Part 1: Interface Definition

3 Mechanical interface

The mechanical interface between LEX-R and LEX-M/LEX-M Base Plate/LEX-C is defined in this section. For the purpose 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:

- The dimensions are in millimeters.
- Third angle projection is used.

3.2 Mechanical references

The reference plane, the reference point and the reference axes of LEX-R and LEX-M/LEX-M Base Plate/LEX-C are defined in Figure 3-1.

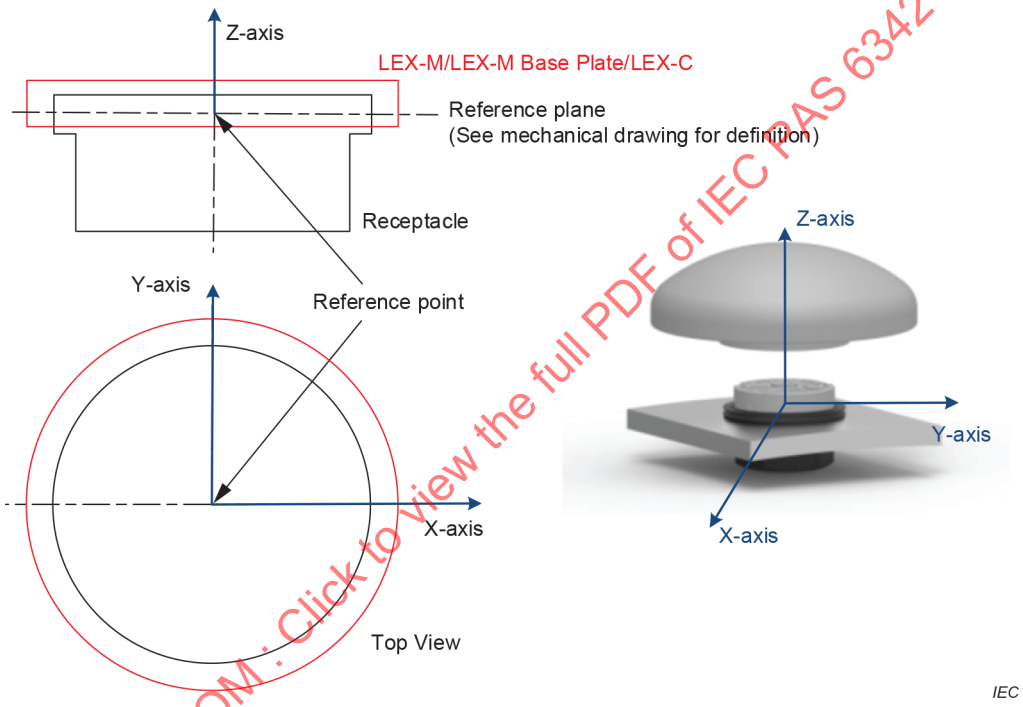


Figure 3-1 – Positions of the reference point, the reference plane and reference axes of the LEX-R and LEX-M

When the LEX-M/LEX-M Base Plate/LEX-C is attached to the LEX-R in locking position, the reference point, the reference plane and the reference axes of both products coincide. For applications where the orientation or the LEX-R to the environment of the Luminaire (for example the street) is important, guidelines are provided in Annex A.

3.3 Definition of the mechanical interface of the Luminaire Extension Module Base Plate

The Luminaire Extension Module Base Plate shall comply with the definition in Figure 3-2, Figure 3-3, Figure 3-4, Figure 3-5, Figure 3-6 and Figure 3-7. Unless indicated otherwise, the tolerance on linear dimensions is ±0.12 mm and the tolerance on angular dimensions is ±1.0º.

The outer diameter of the LEX-M Base Plate shall be less than or equal to 89 mm.

The gasket of the LEX-R should be the only feature imparting the force on the LEX-M Base Plate to ensure locking.

When mated with a gauge as defined in 5.1.1, the mechanical stop features of the LEX-M Base Plate (see Figure 3-6) shall withstand a torque of 5.0 Nm.

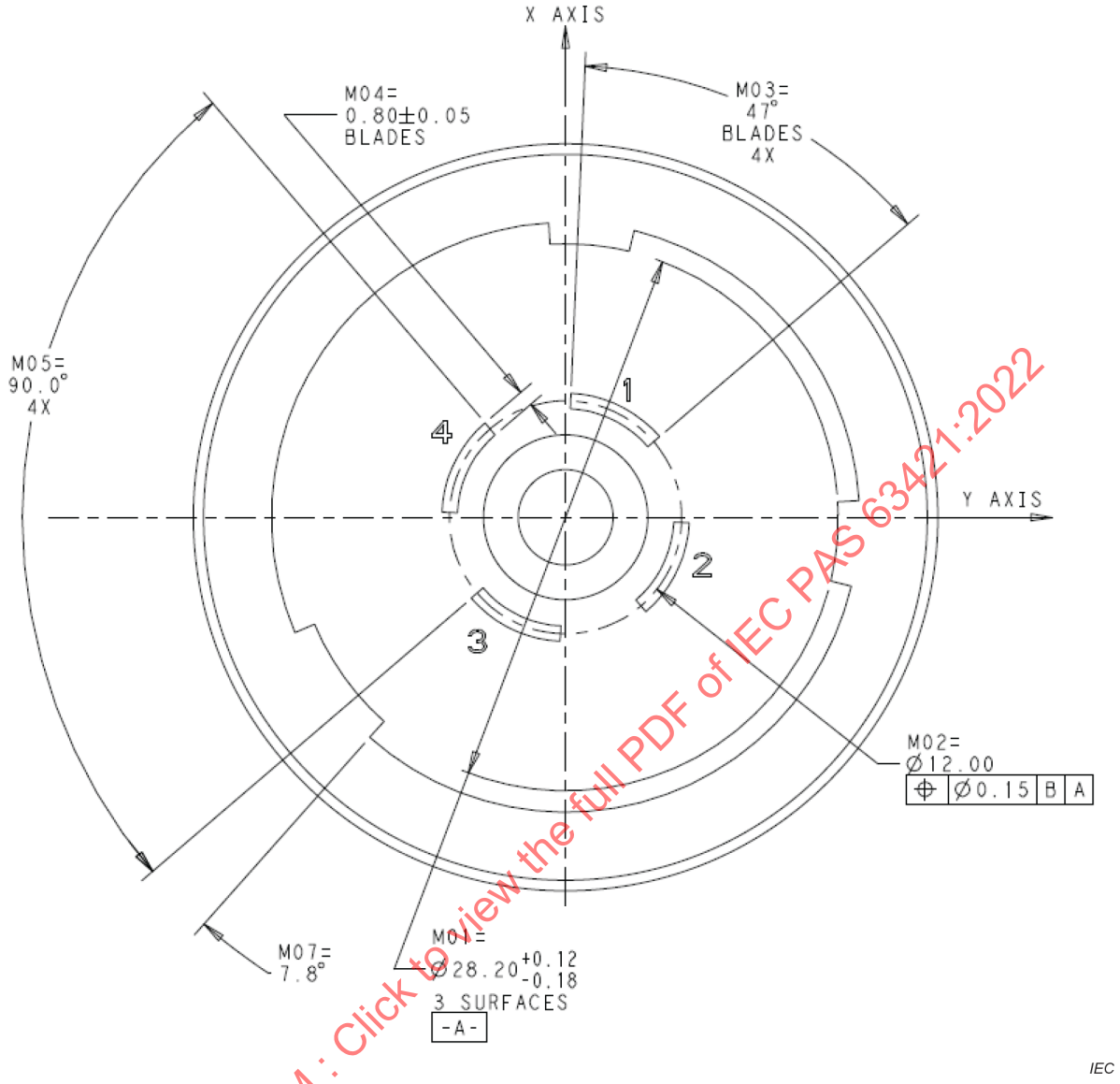


Figure 3-2 – Mechanical interface of the LEX-M Base Plate; Mating face-1

Notes to Figure 3-2:

- X-axis and Y-axis coincide with centerline of locking points as defined in Figure 3-6.

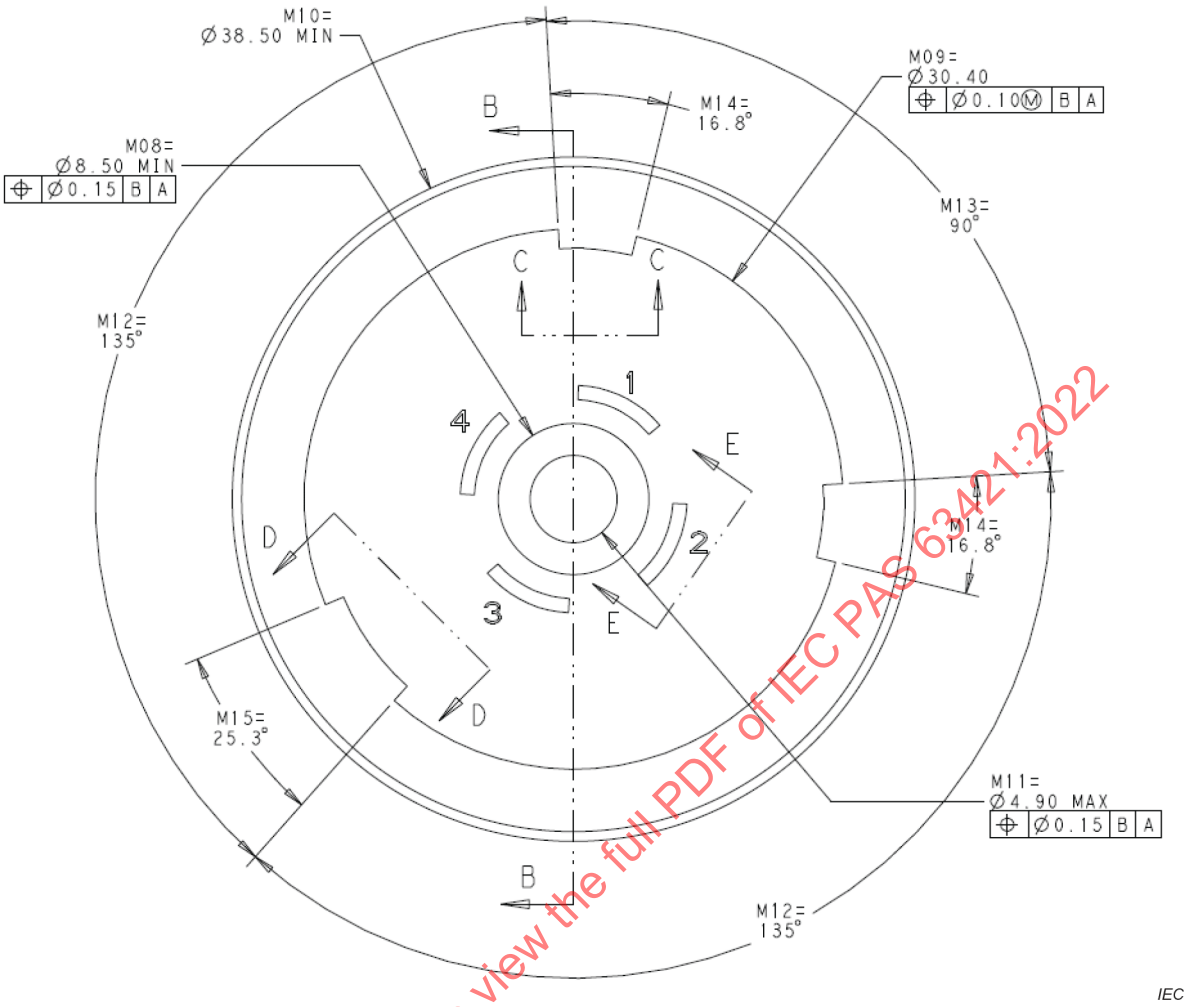


Figure 3-3 – Mechanical interface of the LEX-M Base Plate; Mating face-2

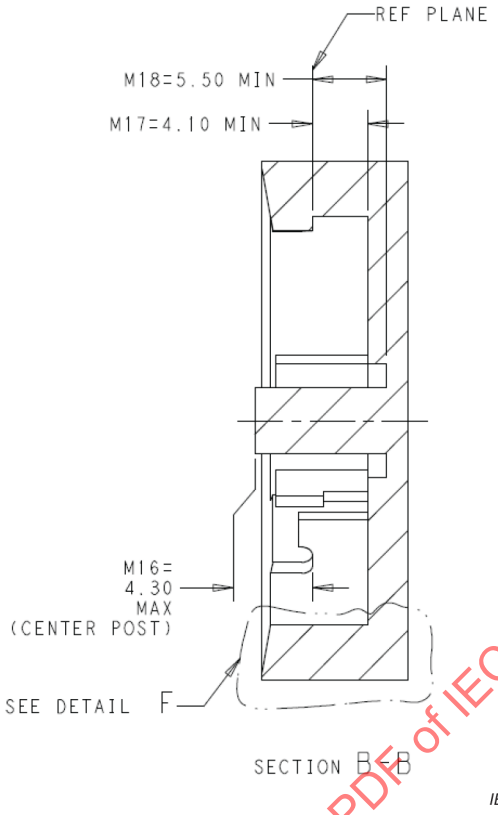


Figure 3-4 – Details of the mechanical interface of the LEX-M Base Plate: section B-B

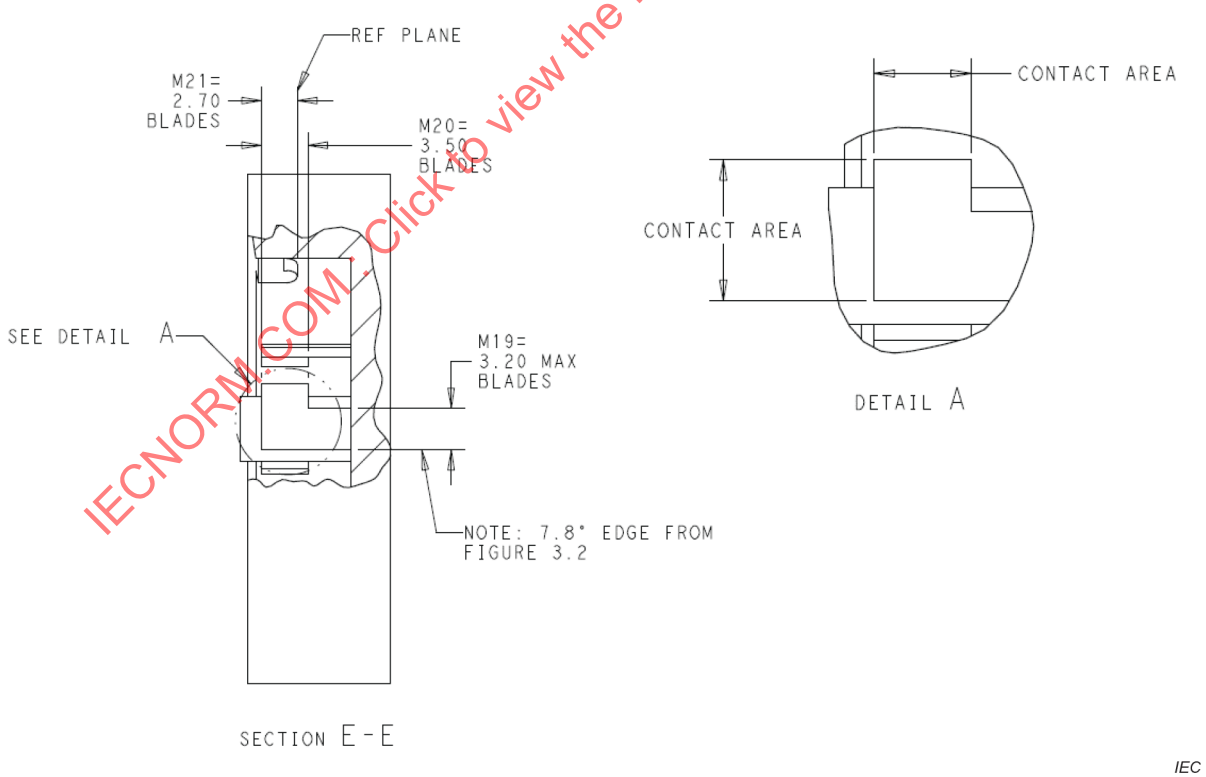


Figure 3-5 – Details of the mechanical interface of the LEX-M Base Plate: section E-E

The contact areas of the LEX-M Base Plate contacts are indicated by 'Contact Area' in Figure 3-5. The contact areas of each contact of the LEX-M Base Plate shall be completely tin plated on both sides.

Informative: Depending on the design of the contacts in the LEX-R, either or both sides of the LEX-M Base Plate contacts can be used for contact making.

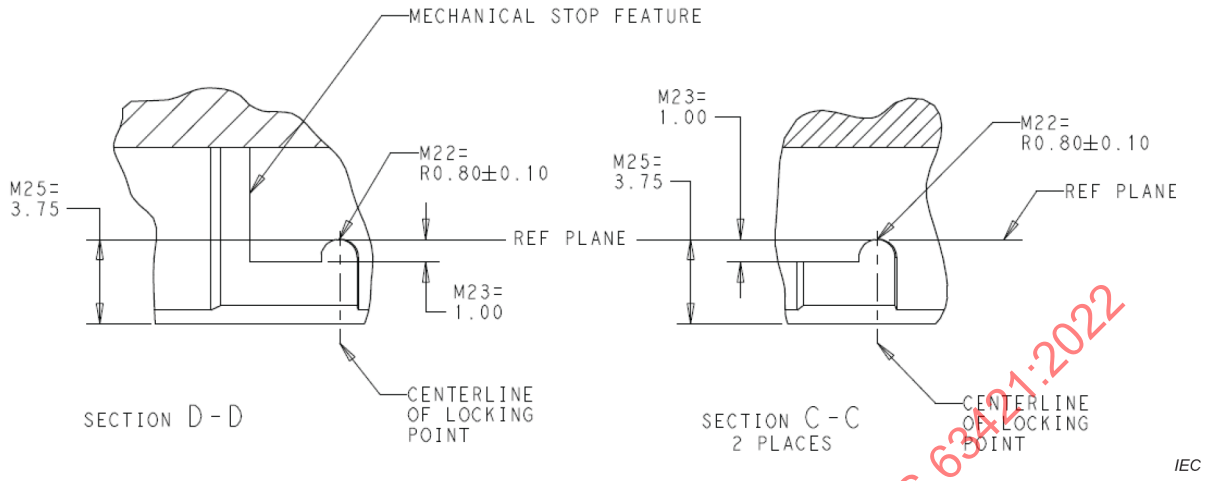


Figure 3-6 – Details of the mechanical interface of the LEX-M Base Plate: section C-C and section D-D

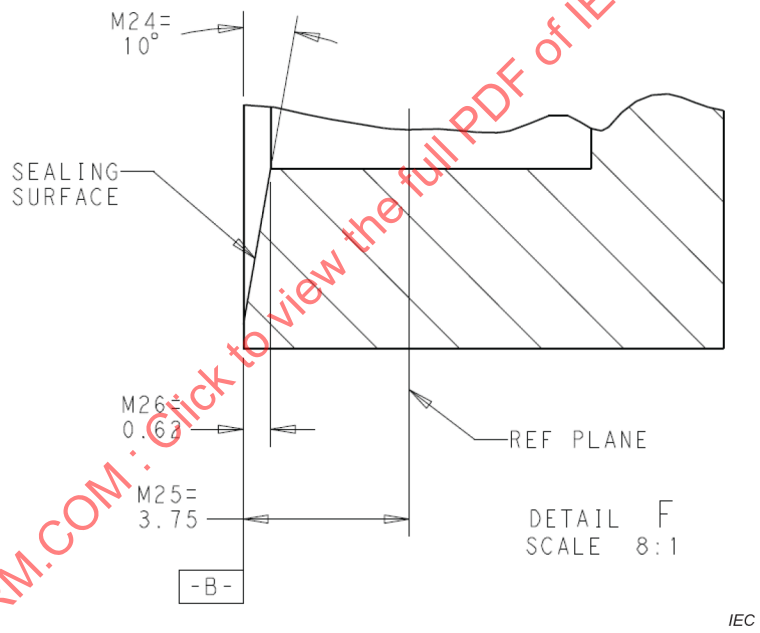


Figure 3-7 – Details of the mechanical interface of the LEX-M Base Plate: section F-F

The sealing surface shall be free of obstacles that can prevent mating[2].

3.4 Definition of the mechanical interface of the Luminaire Extension Cap

The definition of the mechanical interface of the Luminaire Extension Cap is identical to the definition of the mechanical interface of the Luminaire Extension Module Base Plate (section 3.3) except that the Luminaire Extension Cap shall not have contacts.

3.5 Definition of the mechanical interface of the Luminaire Extension Module

The definition of the mechanical interface of the Luminaire Extension Module is identical to the definition of the mechanical interface of the Luminaire Extension Module Base Plate (section 3.3).

2 Note that the seal has two functions: ingress protection and a spring function to keep the module in locked position.

3.5.1 Recommendation for the keep-in volume of the Luminaire Extension Module

In section 3.3, the LEX-M is only limited in diameter and not in height. Especially for a bottom mounted LEX-M this may be a problem as the LEX-M may block the light of the Luminaire, for example in case of an application in a post-top luminaire.

For this reason, it is recommended to limit the outline of the LEX-M such that it fits in the demarcation model depicted as the green area in Figure 3-8.

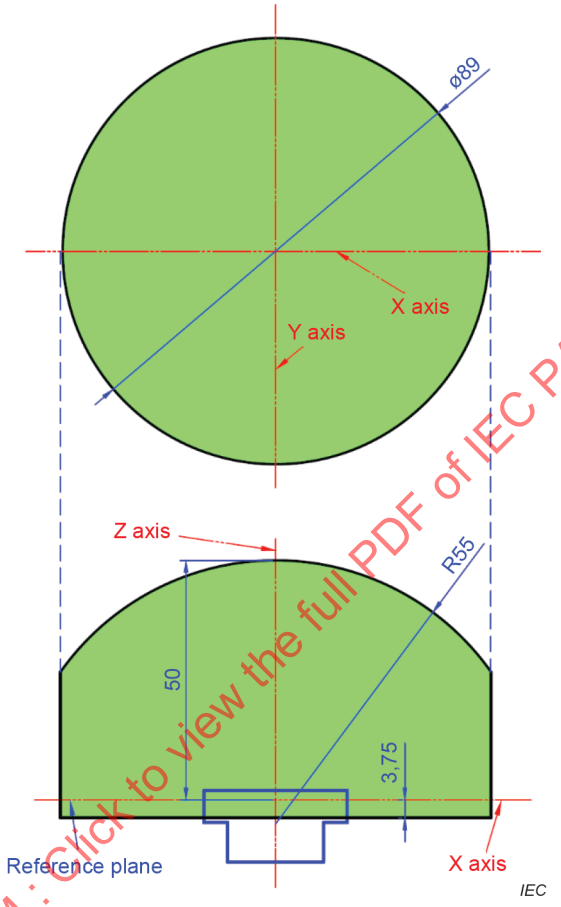


Figure 3-8 – Demarcation model of the LEX-M

3.6 Definition of the mechanical interface of the Luminaire Extension Receptacle

The Luminaire Extension Receptacle shall comply with the definition in Figure 3-9 and Figure 3-10. Unless indicated otherwise, the tolerance on linear dimensions is ±0.12 mm and the tolerance on angular dimensions is ±1.0º.

A LEX-R shall mate with the gauges as defined in sections 5.2.1 and 5.2.2. Moreover, the LEX-R shall have 4 contacts and these contacts shall make electrical contact with the corresponding contacts of the gauges as defined in 5.2.1 and 5.2.2.

The contacts shall be tin plated.

After 5 mating cycles with the gauge defined in section 5.2.3, the torque for un-mating shall be 1.0 Nm or more. During evaluation no downward, axial force shall be applied.

The gasket area as defined in Figure 3-11 shall be free of obstacles that can prevent mating.

The gasket of the LEX-R shall be such that mating and un-mating with a gauge defined in section 5.2.3 is possible with one hand.

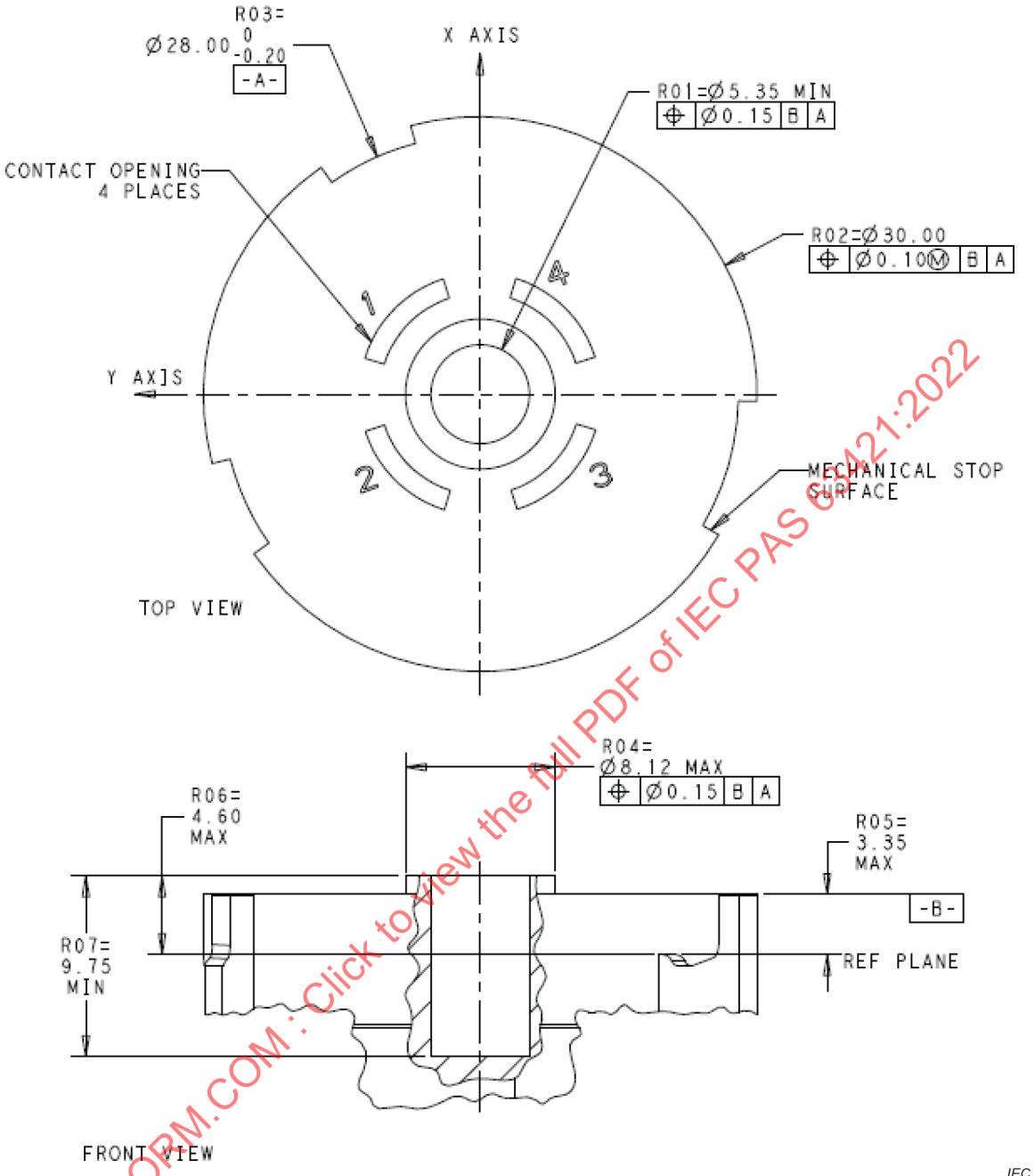


Figure 3-9 – Mechanical interface of the LEX-R. Details in next figure

Notes to Figure 3-9:

- X-axis and Y-axis coincide with centerline of locking point as defined in Figure 3-10.

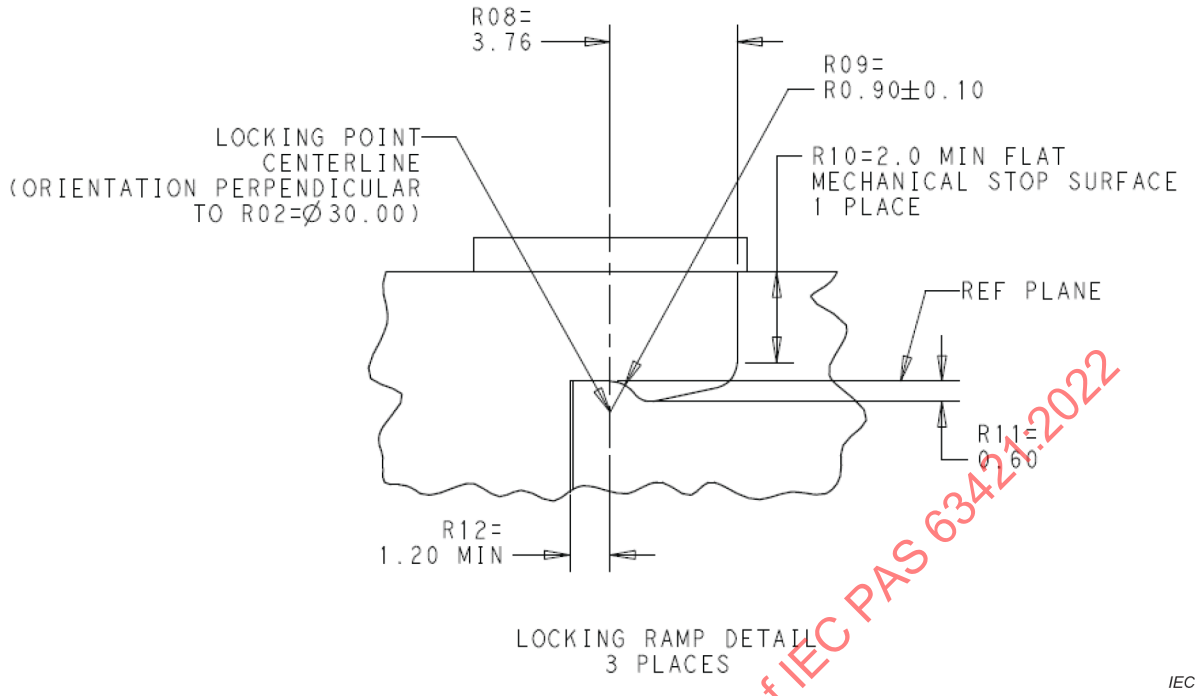


Figure 3-10 – Detail of the mechanical interface of the LEX-R

3.7 Definition of the mechanical interface of the Luminaire

The Luminaire shall feature one or two LEX-Rs. For each LEX-R of the luminaire the requirements in section 3.7.1 shall be met.

3.7.1 Mechanical interface of a LEX-R on the Luminaire

The LEX-R shall comply with specifications in section 3.6 of this specification.

The gasket area and the Luminaire keep-out area are defined in Figure 3-11. Within Luminaire keep-out Area, the top surface of the Luminaire should have no features that protrude above a plane 4.6 mm below the reference plane.

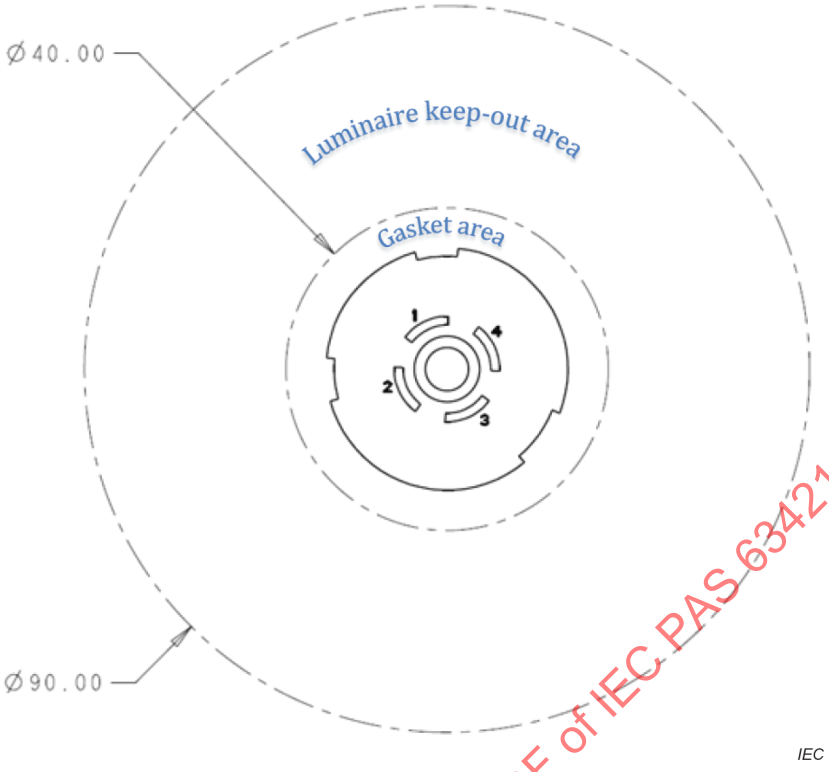


Figure 3-11 – Gasket area and Keep-out area of the Luminaire

4 Electrical & Communication Interface

4.1 Overview (Informative)

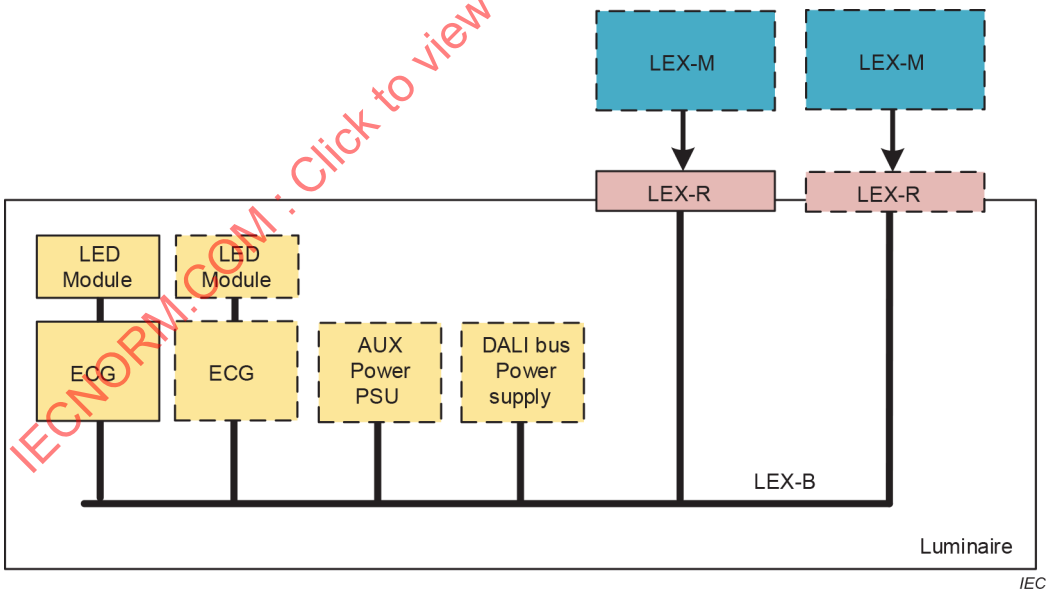


Figure 4-1 – Overview of the Luminaire with LEX-Rs and LEX-Ms

An overview of the Luminaire with LEX-Rs and LEX-Ms is depicted in Figure 4-1. The Luminaire holds one to four ECGs driving the LED Modules and one or two LEX-Rs. Additionally, the Luminaire provides AUX Power supply and a DALI bus power supply. These AUX Power supply and DALI bus power supply may be integrated in the ECGs or provided by separate units.

Two types of LEX-M as defined in [DALI – Part 351] can be attached to the Luminaire. The characteristics of these types are partly listed in Table 4-1.

Table 4-1 – Characteristics of the Type A LEX-M and the Type B LEX-M (informative)

LEX-M Type	Power source	Maximum average power consumption from Aux supply	Maximum peak power consumption from Aux supply	Maximum current consumption from DALI bus	Control
Type A	AUX	2.0 W	5.0 W	2 mA	In case a Type A LEX-M and a Type B LEX-M is attached to the Luminaire, the DALI Application Controller of the Type B LEX-M is disabled, and the DALI Application Controller of the Type A LEX-M controls the system.
Type B Either Bus power **OR** AUX power	AUX	1.0 W	1.0 W	2 mA	
	Bus	-	-	46 mA	

The system is restricted to Luminaires without internal DALI application controllers or input devices and to luminaires that cannot be connected to an external DALI network.

4.1.1 Plug-and-Play

The specifications in this section 4 aim for Plug-and-Play when maximum one Type A LEX-M and maximum one Type B LEX-M is mounted to the Luminaire. 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 motion detector).

However, the LEX-M installer is advised that there are some further limitations to this Plug-and-Play principle. This is indicated in Table 4-2.

Table 4-2 – Plug-and-Play in different system configurations

LEX-Ms attached to the Luminaire	Luminaire with single LEX-R	Luminaire with double LEX-R	
One Type A	Plug-and-Play	Plug-and-Play	
One Type B with integrated Application Controller	Plug-and-Play	Plug-and-Play	
One Type B w/o integrated Application Controller	LEX-M cannot control the ECG	LEX-M cannot control the ECG	
One Type A & One Type B	n.a.	For Type A LEX-M:	Plug-and-Play
		For Type B LEX-M:	May work depending on the specific combination of LEX-Ms. Check datasheets of both LEX-Ms.

4.2 General

The Luminaire shall feature one or two LEX-Rs.

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

The Luminaire shall not comprise emergency lighting control gears that are connected to the LEX-B.

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

4.3 Pin assignment at the Luminaire Extension Interface

The contacts of each LEX-R of the Luminaire shall be connected to the LEX-B according to the assignments as indicated in Table 4-3.

The contacts of the LEX-M shall be connected to the rest of the system according to the assignments as indicated in Table 4-3.

Table 4-3 – Assignments of contacts in the LEX-M and the LEX-R

Contacts		
Module pin number with reference to Figure 3-2	**Receptacle pin number with reference to Figure 3-9**	**Assignment**
1	1	• +24 V AUX Power Supply
2	2	• DA- (Negative pole for the DALI communication and power) • GND for +24 V AUX Power Supply
3	3	• DA+ (Positive pole for the DALI communication and power)
4	4	• Not connected.

4.4 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 manufacturer.

4.4.1 Insulation requirements for the LEX-R

All contacts of each LEX-R of the Luminaire shall be isolated versus mains power according to the requirements for basic isolation as defined in IEC 60598-1.

NOTE All contacts of each LEX-R of the Luminaire may in addition be isolated versus mains power according to the requirements as defined in regional standards or regulations, e.g. UL 1310.

NOTE To accomplish this, the luminaire must use components and be assembled such that the signal and power contacts at the LEX-R provide isolation from mains.

The design of each LEX-R of the Luminaire should be such that the total system of luminaire + LEX-Rs is touch safe if neither a LEX-M nor a LEX-C is mounted to the LEX-Rs.

When no LEX-M is used, a LEX-C should be mounted to the LEX-R to ensure sufficient protection against pollution or damage.

4.4.2 Insulation requirements for the LEX-M

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

4.5 Auxiliary power supply at the Luminaire Extension Interface

4.5.1 Auxiliary power supply requirements for the LEX-R:

In the case the Luminaire features a single LEX-R, the Luminaire shall be capable to provide Auxiliary power supply as specified in [DALI – Part 150] at pins 1 and 2 of this LEX-R.

In the case the Luminaire features two LEX-Rs, the Luminaire shall be capable to provide Auxiliary power supply as specified in [DALI – Part 150] at pins 1 and 2 of both LEX-Rs. However, in this case the parameters as defined in [DALI – Part 150] shall be interpreted as the sum of these parameters of both LEX-Rs.

As an example: "Average output power capability of the power source" is specified in [DALI – Part 150] *to be ≥3.0W. In case of two LEX-Rs, this luminaire shall be capable to provide e.g. 2.0W at the first LEX-R and 1.0W at the second LEX-R. But the Luminaire does not need to be capable to provide 2.0W at the first LEX-R and 2.0W at the second LEX-R.*

On top of the requirements for Luminaires as defined in section 7 of [D4i Requirements], the following requirement shall be met: All AUX power supply units installed in the Luminaire shall be connected to the LEX-B.

4.5.2 Auxiliary power consumption requirements for the LEX-M

If pin 1 of the LEX-M is connected, the LEX-M shall comply with "Electrical specification of AUX supply consumption" as defined [DALI – Part 351] *(Luminaire mounted control devices).*

NOTE In combination with AUX power supply requirements for the LEX-R (section 4.5.1), this restriction guarantees sufficient AUX power supply for the LEX-Ms if maximum one Type A LEX-M and maximum one Type B LEX-M is mounted to the Luminaire.

4.6 Pin 4 at the Luminaire Extension Interface

Pin 4 of each LEX-R of the Luminaire shall not be connected.

Pin 4 of the LEX-M shall not be connected.

NOTE These requirements allow for a standardized definition of the functionality of this pin in future editions of this specification.

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

4.7.1 DALI communication & DALI bus power requirements for the LEX-R

At each LEX-R (pins 2 and 3) 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 section 7 of [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-Ms shall not comprise DALI application controllers nor DALI input devices as defined in [DALI – Part 103].
- A supply current of at least 48 mA shall be available at each one of the two LEX-R interfaces, however the sum of the supply current available simultaneously from the two LEX-R interfaces need not be more than 50 mA.
- The Luminaire shall not feature provisions for connection to an external DALI network.

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

The LEX-M shall meet the requirements for a Type A or a Type B control device as defined in [DALI – Part 351] *(Luminaire mounted control devices).* A LEX-M shall be listed as D4i certified [D4i Requirements] in the DiiA database [DiiA Database].

In case the functionality of the LEX-M includes occupancy sensing or daylight sensing, the LEX-M shall comprise a DALI application controller as defined in [DALI – Part 103].

Part 2: Compliance Tests

5 Compliance test tools

5.1 Test tools for LEX-M and LEX-M base plate

5.1.1 Mechanical-stop-gauge

The Mechanical-stop-gauge is defined in Annex B. This gauge is used to verify whether the mechanical stop features of the LEX-M under test or LEX-M base plate under test (see Figure 3-6) can withstand a torque of 5.0 Nm.

5.2 Luminaire Extension Receptacle test tools

5.2.1 Contact-making-gauge-min

The Contact-making-gauge-min is defined in Annex C. This gauge is used to verify whether the LEX-R under test can mate with a LEX-M that is compliant with this specification and whether all contacts of the LEX-R under test make electrical contact with all contacts of a LEX-M that is compliant with this specification.

5.2.2 Contact-making-gauge-max

The Contact-making-gauge-max is defined in Annex C. This gauge is used to verify whether the LEX-R under test can mate with a LEX-M that is compliant with this specification and whether all contacts of the LEX-R under test make electrical contact with all contacts of a LEX-M that is compliant with this specification.

5.2.3 Un-mating-torque-gauge

The Un-mating-torque-gauge is defined in Annex D. This gauge is used to verify whether after 5 mating cycles of the LEX-R under test with the gauge the torque for un-mating is 1.0 Nm or more.

6 Luminaire Extension Module Base Plate Compliance Tests

6.1 Luminaire Extension Module Base Plate mechanical interface tests

6.1.1 Test of LEX-M Base Plate mechanical dimensions

The purpose of this test is to verify the mechanical dimensions of the Luminaire Extension Module Base Plate under test.

6.1.1.1 Test equipment

None.

6.1.1.2 Test conditions

Not applicable.

6.1.1.3 Test procedure

- The manufacturer provides the mechanical drawing of the Luminaire Extension Module Base Plate under test. This drawing shall include for each dimension listed in Table 6-1, Table 6-2, Table 6-3, Table 6-4, Table 6-5 and Table 6-6 the typical value and the production tolerance.
- Check whether for all dimensions listed in Table 6-1, Table 6-2, Table 6-3, Table 6-4, Table 6-5 and Table 6-6 nominal value and production tolerances are available in the drawing provided by the manufacturer.
- Check whether for all dimensions listed in Table 6-1, Table 6-2, Table 6-3, Table 6-4, Table 6-5 and Table 6-6 the nominal value and production tolerances guarantee products within the tolerance range defined in Table 6-1, Table 6-2, Table 6-3, Table 6-4, Table 6-5 and Table 6-6.
- The manufacturer provides a report of the mechanical measurement of the Luminaire Extension Module Base Plate under test as described in Annex E.
- Check whether measurement results for all dimensions listed in Table 6-1, Table 6-2, Table 6-3, Table 6-4, Table 6-5 and Table 6-6 are available in the report provided by the manufacturer.

- Check whether for all dimensions listed in Table 6-1, Table 6-2, Table 6-3, Table 6-4, Table 6-5 and Table 6-6 the measured value is within the tolerance range.

Table 6-1 – Dimension of the LEX-M Base Plate and LEX-C defined in Figure 3-2

Dimension	Nom. Value	Description	Base plate	Cap	Number of occurrences to check	Tolerance	
						min	max
M01	28.20	Ø indent	√	√	1	-0.18	+0.12
M02	12.0	Ø contact	√		1	-0.12	+0.12
	-	Eccentricity contact	√		1	-	Ø0.15
M03	47º	Contact angle	√		4	-1.0º	+1.0º
M04	0.80	Thickness of contacts	√		4	-0.05	+0.05
M05	90.0º	Relative Contact position	√		4	-1.0º	+1.0º
M07	7.8º	Contact position relative to edge of indent	√		1	-1.0º	+1.0º

Table 6-2 – Dimension of the LEX-M Base Plate and LEX-C defined in Figure 3-3

Dimension	Nom. Value	Description	Base plate	Cap	Number of occurrences to check	Tolerance	
						min	Max
M08	-	Ø center cut-out	√	√	1	8.50	-
	-	Eccentricity cut-out	√	√	1	-	Ø0.15
M09	30.40	Ø cavity	√	√	1	-0.12	+0.12
	-	Max. material eccentricity cavity	√	√	1	-	Ø0.10
M10	-	Ø sealing keep-out area	√	√	1	38.50	-
M11	-	Ø center post	√	√	1	-	4.90
	-	Eccentricity contact	√	√	1	-	Ø0.15
M12	135º	Position of indent (1)	√	√	1	-1.0º	+1.0º
M13	90º	Position of indent (2)	√	√	1	-1.0º	+1.0º
M14	16.8º	Width of indent	√	√	2	-1.0º	+1.0º
M15	25.3º	Width of indent	√	√	1	-1.0º	+1.0º

Table 6-3 – Dimension of the LEX-M Base Plate and LEX-C defined in Figure 3-4

Dimension	Nom. Value	Description	Base plate	Cap	Number of occurrences to check	Tolerance	
						min	Max
M16	-	Length of center post	√	√	1	-	4.30
M17	-	Distance to Ref. plane	√	√	1	4.10	-
M18	-	Distance to Ref. plane	√	√	1	5.50	-

Table 6-4 – Dimension of the LEX-M Base Plate and LEX-C defined in Figure 3-5

Dimension	Nom. Value	Description	Base plate	Cap	Number of occurrences to check	Tolerance	
						min	Max
M19	-	Blade stand width	√		4	-	3.20
M20	3.50	Height of blade	√		4	-0.12	+0.12
M21	2.70	Bottom of blade to Ref. plane	√		4	-0.12	+0.12

Table 6-5 – Dimension of the LEX-M Base Plate and LEX-C defined in Figure 3-6

Dimension	Nom. Value	Description	Base plate	Cap	Number of occurrences to check	Tolerance	
						min	Max
M22	0.80	Radius of locking feature	√	√	3	-0.10	+0.10
M23	1.00	Distance to Ref. plane	√	√	3	-0.12	+0.12

Table 6-6 – Dimension of the LEX-M Base Plate and LEX-C defined in Figure 3-7

Dimension	Nom. Value	Description	Base plate	Cap	Number of occurrences to check	Tolerance	
						min	Max
M24	10º	Ramp of sealing surface	√	√	1	-1.0º	+1.0º
M25	3.75	Bottom of sealing surface to Ref. plane	√	√	3	-0.12	+0.12
M26	0.62	Height of ramp	√	√	1	-0.12	+0.12

6.1.1.4 Pass criteria

The Luminaire Extension Module Base Plate under test passes if for all dimensions listed in Table 6-1, Table 6-2, Table 6-3, Table 6-4, Table 6-5 and Table 6-6 the following holds:

- The mechanical drawing shows compliance with the requirements in section 3.3 within the specified tolerance and
- The measurement report shows compliance with the requirements in section 3.3 within the specified tolerance.

6.1.2 Test of LEX-M Base Plate outer diameter

The purpose of this test is to verify whether the Luminaire Extension Module Base Plate under test is within the limit as defined in section 3.3.

6.1.2.1 Test equipment

Caliper

6.1.2.2 Test conditions

This test shall be conducted at 25 ± 5 ℃.

6.1.2.3 Test procedure

- Measure the outer diameter of the LEX-M Base Plate under test. In case the outer geometry is not circular, the maximum diameter shall be used in this test.

6.1.2.4 Pass criteria

The Luminaire Extension Module Base Plate under test passes if the outer diameter of the LEX-M Base Plate under test is within the limit as defined in section 3.3.

6.1.3 Test of the LEX-M Base Plate mechanical stop features

The purpose of this test is to verify whether mechanical stop features of the LEX-M Base Plate (see Figure 3-6) can withstand a torque of 5.0 Nm.

6.1.3.1 Test equipment

- Mechanical-stop-gauge as defined in 5.1.1.
- Torque meter.

6.1.3.2 Test conditions

This test shall be conducted at 25 ± 5 ℃.

6.1.3.3 Test procedure

- Attach the LEX-M Base Plate under test to the mechanical-stop-gauge.
- Apply for 1 minute a torque of 5 Nm to attach the LEX-M Base Plate with no axial force.
- Apply for 1 minute a torque of 5 Nm to detach the LEX-M Base Plate with no axial force.

6.1.3.4 Pass criteria

The Luminaire Extension Module Base Plate under test passes if the function of mechanical stop is not impaired after the test.

6.1.4 Test of the LEX-M Base Plate sealing surface

The purpose of this test is to verify whether the sealing surface as defined in Figure 3-7 of the LEX-M Base Plate under test is free of obstacles that can prevent mating.

6.1.4.1 Test equipment

None.

6.1.4.2 Test conditions

None.

6.1.4.3 Test procedure

- Inspect visually the sealing surface of the LEX-M Base Plate under test and check whether it is free of obstacles that can prevent mating.

6.1.4.4 Pass criteria

The Luminaire Extension Module Base Plate under test passes if the sealing surface of the LEX-M Base Plate under test is free of obstacles that can prevent mating.

6.1.5 Test of the LEX-M Base Plate contact plating

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

6.1.5.1 Test equipment

None.

6.1.5.2 Test conditions

None.

6.1.5.3 Test procedure

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

6.1.5.4 Pass criteria

The Luminaire Extension Module Base Plate under test passes if the letter of confirmation provided by the LEX-M Base Plate manufacturer indicates that the manufacturer guarantees that the plating of the contacts complies with the restrictions in Table 6-7.

Table 6-7 – 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 Luminaire Extension Cap Compliance Tests

7.1 Luminaire Extension Cap mechanical interface tests

7.1.1 Test of LEX-C mechanical dimensions

In section 6.1.1 the test of mechanical dimensions has been defined for the LEX-M Base Plate. The test for the LEX-C is the same except for two aspects:

- The product under test is the LEX-C rather than the LEX-M Base Plate.
- Only the dimensions with a flag in the column "CAP" in Table 6-1 to Table 6-6 need to be verified.

7.1.2 Test of LEX-C outer diameter

In section 6.1.2 the test of the outer diameter has been defined for the LEX-M Base Plate. The test for the LEX-C is the same except for one aspect: the product under test is the LEX-C rather than the LEX-M Base Plate.

7.1.3 Test of the LEX-C mechanical stop features

In section 6.1.3 the test of the mechanical stop features has been defined for the LEX-M Base Plate. The test for the LEX-C is the same except for one aspect: the product under test is the LEX-C rather than the LEX-M Base Plate.

7.1.4 Test of the LEX-C sealing surface

In section 6.1.4 the test of the sealing surface has been defined for the LEX-M Base Plate. The test for the LEX-C is the same except for one aspect: the product under test is the LEX-C rather than the LEX-M Base Plate.

8 Luminaire Extension Receptacle compliance tests

8.1 Luminaire Extension Receptacle mechanical interface tests

8.1.1 Test of mechanical dimensions

The purpose of this test is to verify the mechanical dimensions of the Luminaire Extension Receptacle under test.

8.1.1.1 Test equipment

None.

8.1.1.2 Test conditions

Not applicable.

8.1.1.3 Test procedure

- The manufacturer provides the mechanical drawing of the Luminaire Extension Receptacle under test. This drawing shall include for each dimension listed in Table 8-1 and Table 8-2 the typical value and the production tolerance.
- Check whether for all dimensions listed in Table 8-1 and Table 8-2 nominal value and production tolerances are available in the drawing provided by the manufacturer.
- Check whether for all dimensions listed in Table 8-1 and Table 8-2 the nominal value and production tolerances guarantee products within the tolerance range defined in Table 8-1 and Table 8-2.
- The manufacturer provides a report of the mechanical measurement of the Luminaire Extension Receptacle under test as described in Annex E.
- Check whether measurement results for all dimensions listed in Table 8-1 and Table 8-2 are available in the report provided by the manufacturer.
- Check whether for all dimensions listed in Table 8-1 and Table 8-2 the measured value is within the tolerance range.

Table 8-1 – Dimension of the LEX-R defined in Figure 3-9

Dimension	Nom. Value	Description	Number of occurrences to check	Tolerance	
				min	max
R01	-	Ø hole for center post	1	5.35	-
	-	Eccentricity hole for pole	1	-	Ø0.15
R02	30.0	Ø outline	1	-0.12	+0.12
		Max. material eccentricity outline	1	-	Ø0.10
R03	28.0	Ø indent	1	-0.20	+0.00
R04	-	Width of center ring	1	-	8.12
	-	Eccentricity of center ring	1	-	Ø0.15
R05	-	Height of top surface	1	-	3.35
R06	-	Height of center ring	1	-	4.60
R07	-	Depth of center hole	1	9.75	-

Table 8-2 – Dimension of LEX-R defined in Figure 3-10

Dimension	Nom. Value	Description	Number of occurrences to check	Tolerance	
				min	max
R08	3.76	Locking point to edge	3	-0.12	+0.12
R09	0.90	Curvature of locking point	3	-0.10	+0.10
R10	-	Mechanical stop	1	2.00	-
R11	0.60	Lock bump	3	-0.12	+0.12
R12	-	Position locking point	3	1.20	-

8.1.1.4 Pass criteria

The Luminaire Extension Receptacle under test passes if for all dimensions listed in Table 8-1 and Table 8-2 the following holds:

- The mechanical drawing shows compliance with the requirements in section 3.6 within the specified tolerance and
- The measurement report shows compliance with the requirements in section 3.6 within the specified tolerance.

8.1.2 Test of the LEX-R mating & contact making

The purpose of this test is to verify that the LEX-R under test can mate with a LEX-M that is compliant with this specification and that all contacts of the LEX-R under test make electrical contact with all contacts of a LEX-M that is compliant with this specification.

8.1.2.1 Test equipment

- Contact-making-gauge-min as defined in 5.2.1.
- Contact-making-gauge-max as defined in 5.2.2.
- Ohms meter or contact making tester.

8.1.2.2 Test conditions

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

8.1.2.3 Test procedure

- Mount the LEX-R under test, including gasket according to the manufacturer's instruction on a flat plate.
- Attach the contact-making-gauge-min to the LEX-R under test. Check whether the gauge fits the LEX-R under test without undue force and whether all 4 electrical connections are established.
- Attach the contact-making-gauge-max to the LEX-R under test. Check whether the gauge fits the LEX-R under test without undue force and whether all 4 electrical connections are established.

8.1.2.4 Pass criteria

The Luminaire Extension Receptacle under test passes if the test result confirms that both gauges fit the LEX-R under test and if with both gauges, all 4 electrical connections are established.

8.1.3 Test of the LEX-R mating and un-mating torque

The first purpose of this test is to verify whether after 5 mating cycles with the gauge defined in section 5.2.3, the torque for un-mating is 1.0 Nm or more.

The second purpose of this test is to verify if the gasket of the LEX-R is such that mating and un-mating with a gauge defined in section 5.2.3 is possible with one hand.

The third purpose of the test is to verify that the gasket area as defined in Figure 3-11 is free of obstacles that can prevent mating.

8.1.3.1 Test equipment

- Un-mating-torque-gauge as defined in 5.2.3.
- Torque meter.

8.1.3.2 Test conditions

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

8.1.3.3 Test procedure

- Mount the LEX-R under test, including gasket according to the manufacturer's instruction on a flat plate.
- Perform 5 mating sequences with the un-mating-torque-gauge and the LEX-R under test. The test shall be performed with one hand and no axial force shall be applied.
- Measure the torque required to detach the un-mating-torque-gauge from the LEX-R under test. During this measurement no axial force shall be applied.

8.1.3.4 Pass criteria

The Luminaire Extension Receptacle under test passes if the test can be performed with one hand and the measured torque is 1.0 Nm or more.

8.1.4 Test of the LEX-R contact plating

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

8.1.4.1 Test equipment

None.

8.1.4.2 Test conditions

None.

8.1.4.3 Test procedure

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

8.1.4.4 Pass criteria

The Luminaire Extension Receptacle under test passes if the letter of confirmation provided by the LEX-R manufacturer indicates that the manufacturer guarantees that the plating of the contacts complies with the restrictions in Table 8-3.

Table 8-3 – 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

9 Luminaire Extension Module compliance tests

9.1 Luminaire Extension Module mechanical interface tests

9.1.1 Test of mechanical dimensions

The purpose of this test is to verify the mechanical dimensions of the Luminaire Extension Module under test.

This compliance test is not required in case the Luminaire Extension Module under test features a Zhaga certified Luminaire Extension Module Base plate.

In case the Luminaire Extension Module under test does not feature a Zhaga certified Luminaire Extension Module Base plate, this test shall be conducted. In section 6.1.1. the test of mechanical dimensions has been defined for the LEX-M Base Plate. The test for the LEX-M is the same except for one aspect: the product under test is the LEX-M rather than the LEX-M Base Plate.

9.1.2 Test of LEX-M outer diameter

The purpose of this test is to verify whether the Luminaire Extension Module under test is within the limit as defined in section 3.3.

9.1.2.1 Test equipment

Caliper.

9.1.2.2 Test conditions

This test shall be conducted at 25 ± 5 ℃.

9.1.2.3 Test procedure

- Measure the outer diameter of the LEX-M under test. In case the outer geometry is not circular, the maximum diameter shall be used in this test.

9.1.2.4 Pass criteria

The Luminaire Extension Module under test passes if the outer diameter of the LEX-M under test is within the limit as defined in section 3.3.

9.1.3 Test of the LEX-M mechanical stop features

The purpose of this test is to verify whether mechanical stop features of the LEX-M (see Figure 3-6) can withstand a torque of 5.0 Nm.

This compliance test is not required in case the Luminaire Extension Module under test features a Zhaga certified Luminaire Extension Module Base plate.

In case the Luminaire Extension Module under test does not feature a Zhaga certified Luminaire Extension Module Base plate, this test shall be conducted. In section 6.1.3. the test of mechanical stop features has been defined for the LEX-M Base Plate. The test for the LEX-M is the same except for one aspect: the product under test is the LEX-M rather than the LEX-M Base Plate.

9.1.4 Test of the LEX-M Plate sealing surface

The purpose of this test is to verify whether the sealing surface of the LEX-M under test is free of obstacles that can prevent mating.

9.1.4.1 Test equipment

None.

9.1.4.2 Test conditions

None.

9.1.4.3 Test procedure

- Inspect visually the sealing surface of the LEX-M under test and check whether it is free of obstacles that can prevent mating.

9.1.4.4 Pass criteria

The Luminaire Extension Module under test passes if the sealing surface of the LEX-M under test is free of obstacles that can prevent mating.

9.1.5 Test of the LEX-M contact plating

The purpose of this test is to check whether the plating to the contact areas of the LEX-M contains the minimum proportion of tin required by this specification.

This compliance test is not required in case the Luminaire Extension Module under test features a Zhaga certified Luminaire Extension Module Base plate.

In case the Luminaire Extension Module under test does not feature a Zhaga certified Luminaire Extension Module Base plate, this test shall be conducted. In section 6.1.5. the test of contact plating has been defined for the LEX-M Base Plate. The test for the LEX-M is the same except for one aspect: the product under test is the LEX-M rather than the LEX-M Base Plate.

9.2 Luminaire Extension Module electrical interface tests

9.2.1 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].

9.2.2 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 4-3.

9.2.2.1 Test equipment

None.

9.2.2.2 Test conditions

None.

9.2.2.3 Test procedure

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

9.2.2.4 Pass criteria

The Luminaire Extension Module under test passes if the letter of confirmation provided by the LEX-M manufacturer indicates that.

- Pin 1 is either not connected or used for AUX power supply and not used for other purposes.
- Pin 2 is used for DA- (Negative pole for the DALI communication and power) and optionally for GND for +24 V AUX Power Supply and not used for other purposes.
- Pin 3 is used for DA+ (Positive pole for the DALI communication and power) and not used for other purposes.
- Pin 4 is not connected.

9.2.3 Test of the LEX-M AUX power requirements

The purpose of this test is to verify whether the LEX-M meets the AUX power requirements as listed in section 4.5.2.

9.2.3.1 Test equipment

None.

9.2.3.2 Test conditions

None.

9.2.3.3 Test procedure

Check whether the LEX-M under test is listed in [DiiA Database] and whether this listing indicates that the LEX-M is listed as D4i certified [D4i Requirements].

9.2.3.4 Pass criteria

The Luminaire Extension Module under test passes if the LEX-M under test is listed in [DiiA Database] and if this listing indicates that the LEX-M is listed as D4i certified [D4i Requirements].

9.2.4 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.

9.2.4.1 Test equipment

None.

9.2.4.2 Test conditions

None.

9.2.4.3 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) and that the LEX-M is a Type A Control Device or a Type B Control Device as defined in* [DALI – Part 351].
- In case the functionality of the LEX-M includes occupancy sensing or daylight sensing, inspect the letter of confirmation provided by the LEX-M manufacturer and check whether it

is confirmed that the LEX-M comprises a DALI application controller as defined in [DALI – Part 103].

9.2.4.4 Pass criteria

The Luminaire Extension Module under test passes if the LEX-M meets the condition listed in section 9.2.4.3.

10 Luminaire compliance tests

10.1 General

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

10.2 Luminaire mechanical Interface tests

10.2.1 Test of the mechanical interface of the LEX-R

The purpose of this test is to verify the mechanical interface of each Luminaire Extension Receptacle of the Luminaire under test.

This compliance test is not required in case all LEX-Rs of the Luminaire are Zhaga certified products.

In case a LEX-R of the Luminaire under test is not a Zhaga certified LEX-R, all tests on the mechanical interface of the LEX-R as defined in section 8.1 shall be conducted on that LEX-R.

10.2.2 Test of the keep-out zone of LEX-R(s)

The purpose of this test is to verify that within the Luminaire keep-out Area as defined in Figure 3-11, the top surface of the Luminaire does not have mechanical features that protrude above a plane 4.6 mm below the reference plane.

10.2.2.1 Test equipment

Caliper.

10.2.2.2 Test conditions

None.

10.2.2.3 Test procedure

Inspect the Luminaire keep-out Area of Luminaire housing and check whether any mechanical features are present that protrude above a plane 4.6 mm below the reference plane.

10.2.2.4 Pass criteria

The Luminaire under test passes if within the Luminaire keep-out Area, the top surface of the Luminaire does not have mechanical features that protrude above a plane 4.6 mm below the reference plane.

10.3 Luminaire electrical Interface tests

10.3.1 Test of the number of LEX-Rs

The purpose of this test is to verify that the Luminaire features one or two LEX-Rs.

10.3.1.1 Test equipment

None.

10.3.1.2 Test conditions

None.

10.3.1.3 Test procedure

Inspect the Luminaire or its circuit diagram and count the number of LEX-Rs.

10.3.1.4 Pass criteria

The Luminaire under test passes if it features one or two LEX-Rs.

10.3.2 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].

10.3.2.1 Test equipment

None.

10.3.2.2 Test conditions

None.

10.3.2.3 Test procedure

Inspect the letter of confirmation provided by the Luminaire manufacturer.

10.3.2.4 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].

10.3.3 Test on Emergency control gears

The purpose of this test is to verify that the Luminaire under test does not comprise emergency control gears that are connected to the LEX-B.

10.3.3.1 Test equipment

None.

10.3.3.2 Test conditions

None.

10.3.3.3 Test procedure

Inspect the Luminaire or its circuit diagram provided by the Luminaire manufacturer and check whether the Luminaire under test comprises one or more emergency control gears that are connected to the LEX-B.

10.3.3.4 Pass criteria

The Luminaire under test passes if the Luminaire under test does not comprise emergency control gears that are connected to the LEX-B.

10.3.4 Test of the Luminaire pin assignment

The purpose of this test is to verify whether the pin assignment of the Luminaire complies with Table 4-3.

10.3.4.1 Test equipment

None.

10.3.4.2 Test conditions

None.

10.3.4.3 Test procedure

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

- Pin 1 is connected to the LEX-B line for AUX power supply and not used for other purposes.
- Pin 2 is connected to the LEX-B line for DA- (Negative pole for the DALI communication and power) and for GND for AUX Power Supply and not used for other purposes.

- Pin 3 is connected to the LEX-B line for DA+ (Positive pole for the DALI communication and power) and not used for other purposes.
- Pin 4 is not connected.

10.3.4.4 Pass criteria

The Luminaire under test passes if all conditions listed in section 10.3.4.3 are met.

10.3.5 Test of the Luminaire electrical insulation

The purpose of this test is to verify whether the Luminaire complies with the requirements on electrical insulation as listed in section 4.4.1.

10.3.5.1 Test equipment

None.

10.3.5.2 Test conditions

None.

10.3.5.3 Test procedure

Inspect the letter of confirmation provided by the Luminaire manufacturer.

10.3.5.4 Pass criteria

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

10.3.6 Test of the Luminaire AUX power requirements

The purpose of this test is to verify whether the Luminaire meets the AUX power supply requirements as listed in section 4.5.1.

10.3.6.1 Test equipment

None.

10.3.6.2 Test conditions

None.

10.3.6.3 Test procedure

Inspect the circuit diagram of the Luminaire under test and check whether the following condition is met:

- Each device providing AUX power supply (either integrated in the ECG or as PSU) in the Luminaire under test is connected to the LEX-B.

10.3.6.4 Pass criteria

The Luminaire under test passes if the condition listed in section 10.3.6.3 is met.

10.3.7 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 4.7.2.

10.3.7.1 Test equipment

None.

10.3.7.2 Test conditions

None.

10.3.7.3 Test procedure

- In case the luminaire contains only D4i ECGs, inspect the circuit diagram of the Luminaire under test and check whether the following conditions are met:
  - All 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 network.
- In case the luminaire contains only DALI-2 ECGs, inspect the circuit diagram of the Luminaire under test and check whether the following conditions are met:
  - All 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 network.
- Inspect the letter of confirmation provided by the Luminaire manufacturer.

10.3.7.4 Pass criteria

In case the luminaire contains only D4i ECGs, the Luminaire under test passes if:

- all conditions for luminaires with D4i ECGs as listed in section 10.3.7.3 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].

In case the luminaire contains only DALI-2 ECGs, the Luminaire under test passes if:

- all conditions for luminaires with DALI-2 ECGs as listed in section 10.3.7.3 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].

In all other cases the luminaire under test fails this test.

Annex A

Application guidelines

The Luminaire Extension Receptacles and the Luminaire Extension Modules are intended to be used in outdoor applications. In some of these applications, the orientation of the LEX-M with respect to its environment is essential for proper functioning. For applications where this is the case, it is important that the orientation is correct also after attaching a new LEX-M, possibly from another brand. In order to facilitate this, the recommended orientations are defined for several applications.

It is also recommended that information on the orientation and mounting of the LEX-M and LEX-R is available in the product documentation.

A.1 Street lighting

For the street lighting application, it is recommended that the Luminaire and the LEX-R in the Luminaire are mounted such that the Y-axis of the receptacle is perpendicular to the road and is pointing towards the center of the road. See Figure A-1.

Also, for this application it is recommended that the LEX-M is constructed assuming that the Luminaire and the LEX-R in the luminaire are mounted such that the Y-axis of the receptacle is perpendicular to the road and is pointing towards the center of the road.

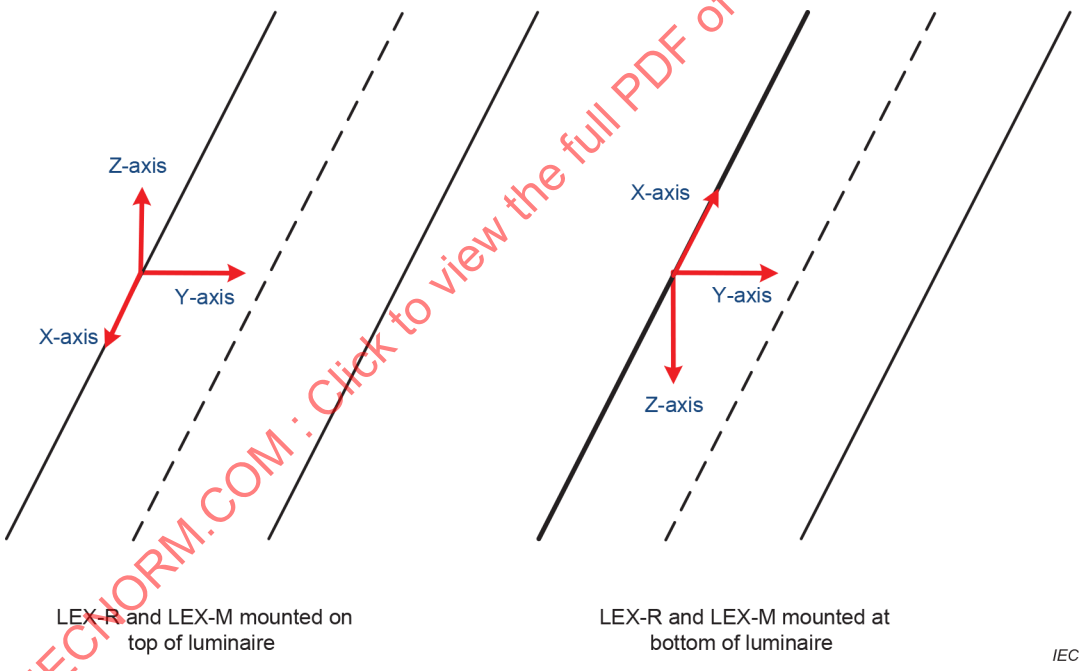


Figure A-1 – Orientation for LEX-R and LEX-M in street lighting applications

A.2 Bottom mounted LEX-M

When a LEX-M is mounted to the bottom-side of a Luminaire, it is beneficial that the LEX-M manufacturer knows upfront which field of view is free for its sensor functionality. For example, the position and orientation of the LEX-M with respect to luminaire pole can be critical. For this reason, guidelines for this application have been listed in this annex.

The blocked viewing angle of the LEX-M should be less than 60°. This blocked viewing angle should be located within an angle of 2x55° with perpendicular reference to the street as depicted in Figure A-2.

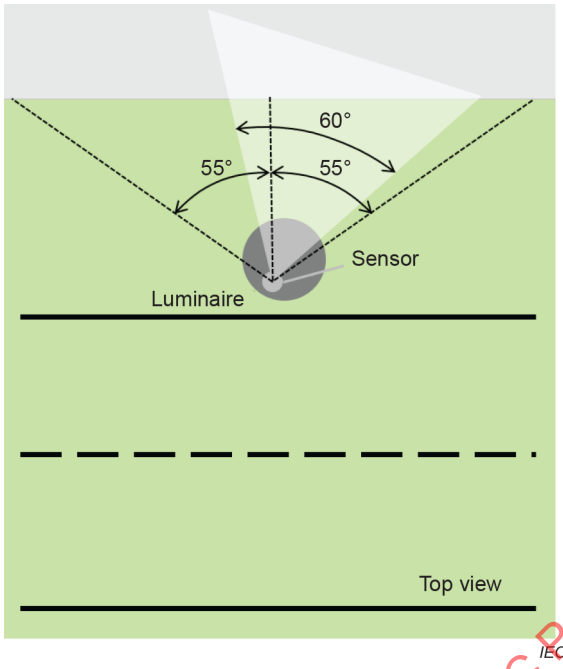


Figure A-2 – Maximum blocked viewing angle of the LEX-M

All the space below an angle of 5 degrees from the horizon, starting from the central axis of the LEX-R, should be free of materials in the non-blocked viewing angle (as defined in Figure A-2) and the green zone in Figure A-3.

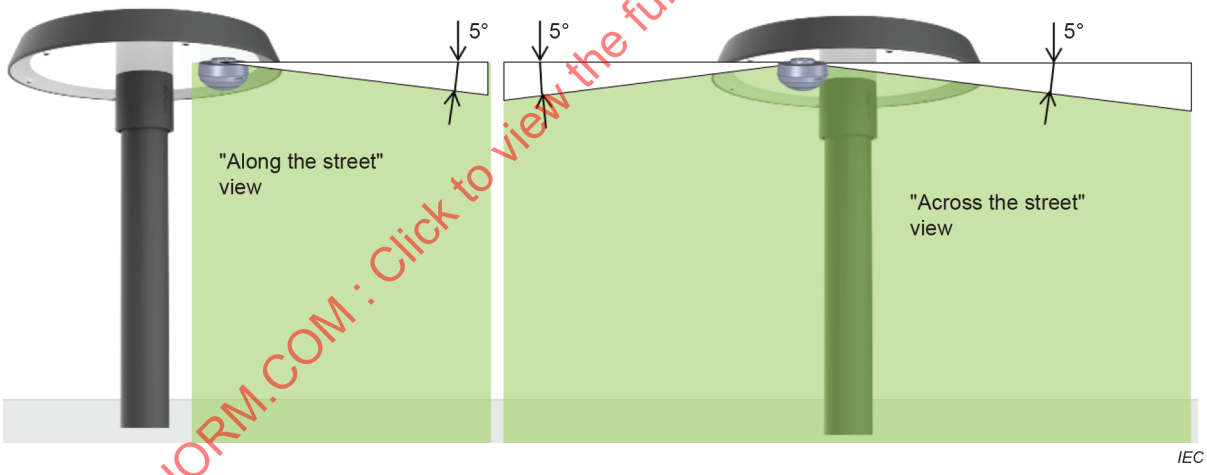
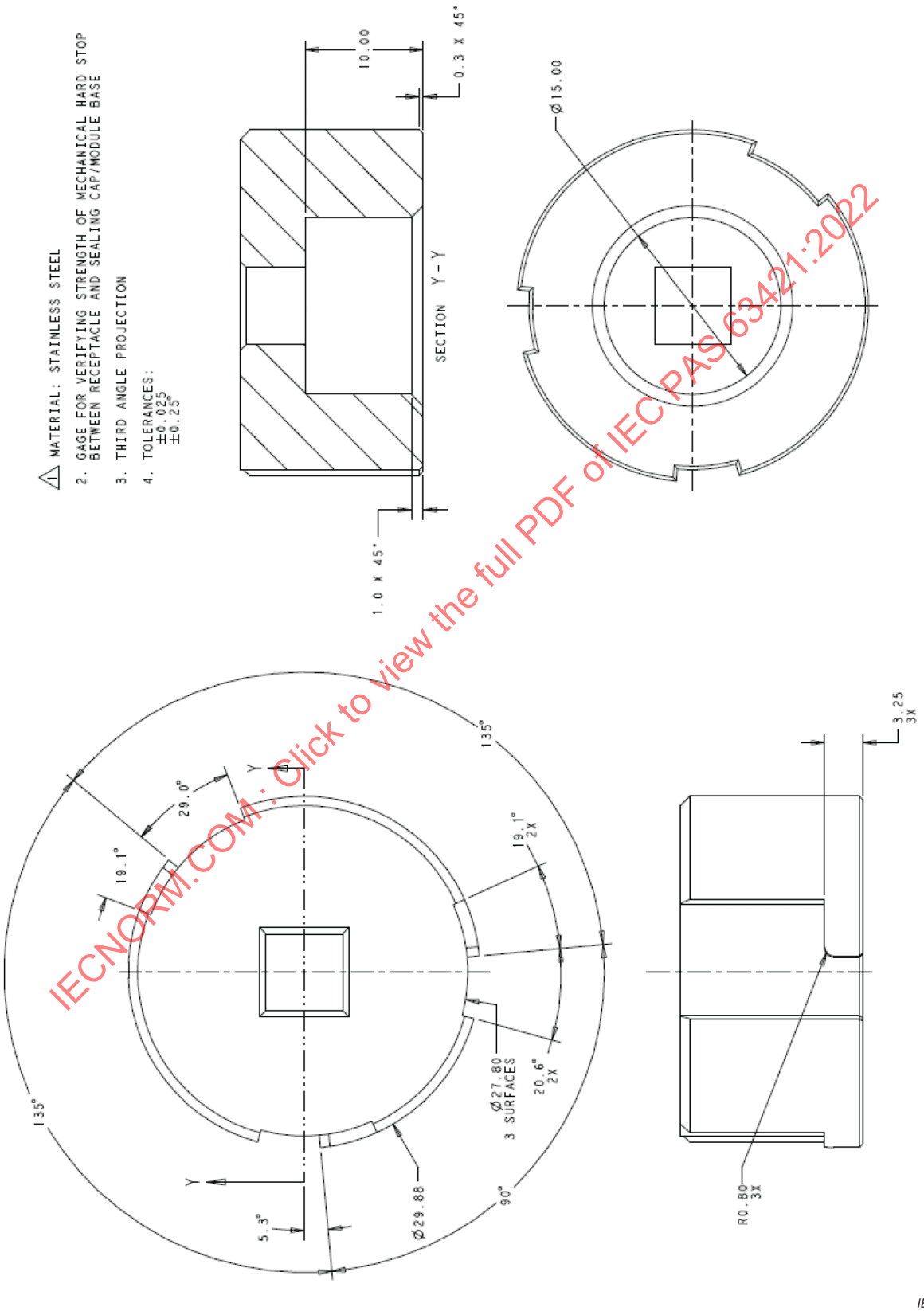


Figure A-3 – Maximum blocked viewing angle of the LEX-M

Mounting angle of the LEX-M should be +/- 15 degrees from the horizon, taking into account all tilt-angles of the luminaire.

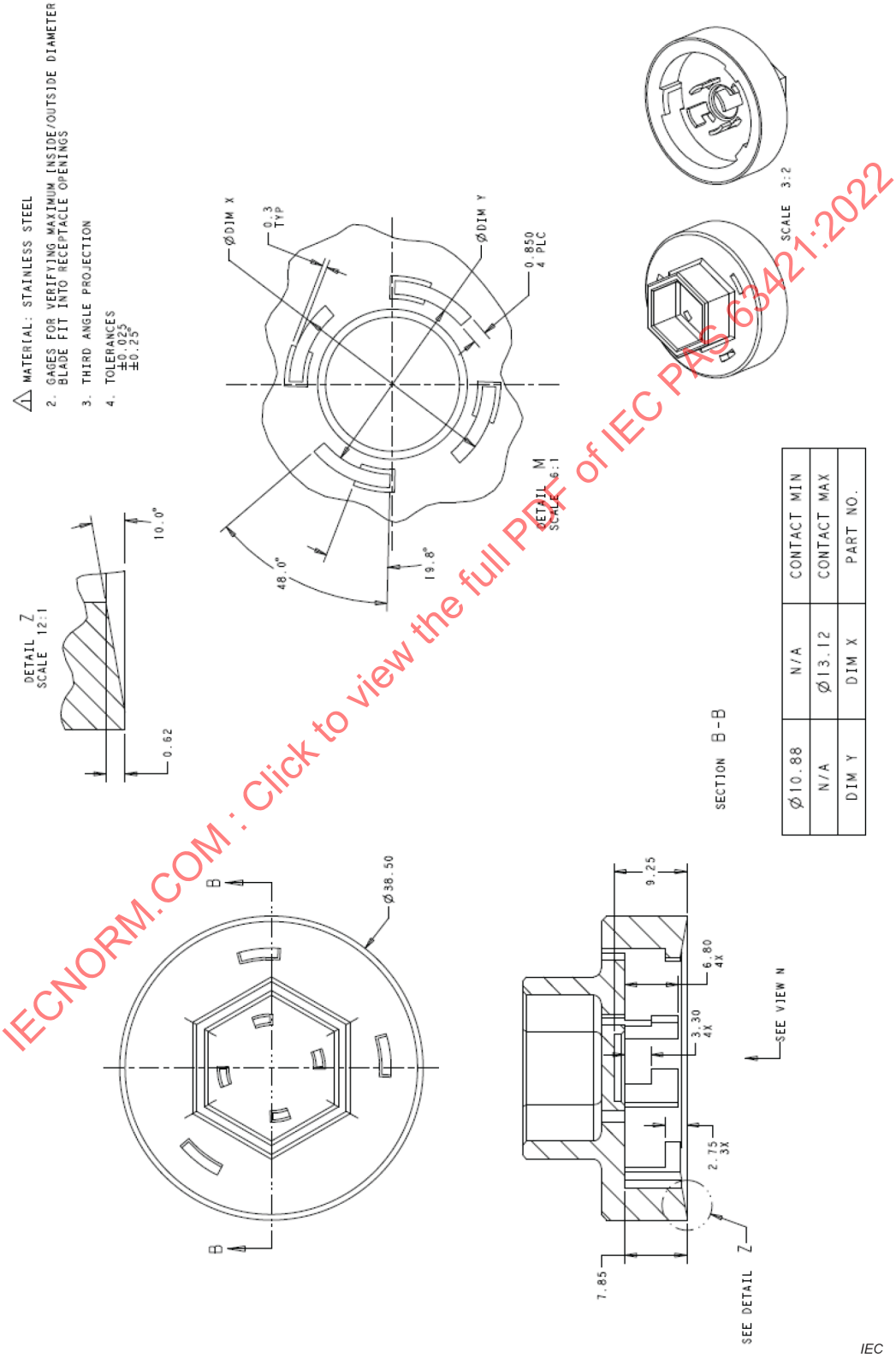
Annex B

Mechanical drawing of the Mechanical-stop-gauge



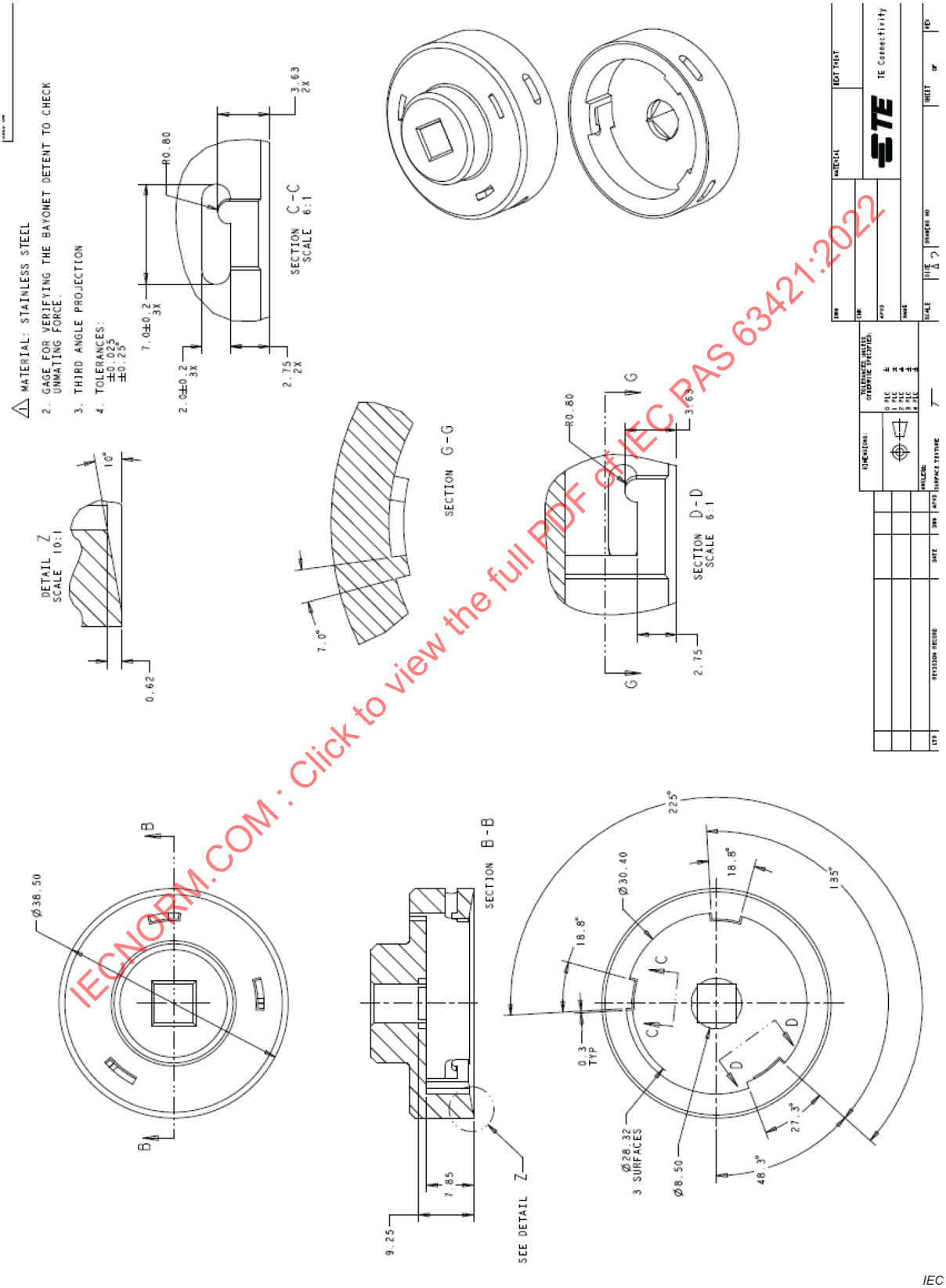
Annex C

Mechanical drawings of the Contact-making-gauge-min and Contact-making-gauge-max



Annex D

Mechanical drawing of the Un-mating-torque-gauge



Annex E

LEX-M baseplate and LEX-R mechanical interface tests (Informative)

E.1 LEX-M baseplate mechanical interface tests

E.1.1 Test of mechanical dimensions

The purpose of this test is to verify the mechanical dimensions of the Luminaire Extension Module baseplate under test.

E.1.2 Test equipment

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

This test may be conducted by optical or tactile measurement techniques but in this case the LEX-M baseplate under test will need to be sectioned in order to measure certain dimension. Alternatively, topographic techniques may be used.

E.1.2.1 Test conditions

This test shall be conducted at 25 ± 5 ℃.

E.1.2.2 Test procedure

- Measure all dimensions listed in Table 6-1, Table 6-2, Table 6-3, Table 6-4, Table 6-5 and Table 6-6.

E.2 LEX-R mechanical interface tests

E.2.1 Test of mechanical dimensions

The purpose of this test is to verify the mechanical dimensions of the Luminaire Extension Receptacle under test.

E.2.1.1 Test equipment

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

This test may be conducted by optical or tactile measurement techniques but in this case the LEX-R under test will need to be sectioned in order to measure certain dimension. Alternatively, topographic techniques may be used.

E.2.1.2 Test conditions

This test shall be conducted at 25 ± 5 ℃.

E.2.1.3 Test procedure

- Measure all dimensions listed in Table 8-1 and Table 8-2.

Annex F

History of Changes

Table F-1 – Changes from Edition 1.1 to Edition 2.0

Location	Change
Section 1.3	New references to DiiA documents
Section 3	Added mechanical interface definition of LEX-M base plate
Section 4	New definition of electrical and communication interface
Section 6	Added compliance tests for LEX-M base plate
Section 9.2	New compliance tests for electrical and communication interface of the LEX-M
Section 10	New compliance tests for the Luminaire

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[3]

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

[3] The definitions are possibly further restricted in the other Zhaga books.

	ECG and without any additional enclosure. This may consist of a Built-in ECG housed in a suitable enclosure which provides all the necessary protections according to its marking.
Integrated ECG	An ECG of a LLE that is accommodated in the same housing as the LED module(s) of the LLE. This combination is an Integrated LED Light Engine.
Integrated LED Light Engine	A LED Light Engine that consists of a single housing. This is the same as a "LED Light Engine with Integrated ECG". Note that a module, complying with a specific Book that describes a LLE with Separate ECG but that is directly connected to external power would be an Integrated LLE and thus would be out of scope of that Book.
Interchangeable	Two Zhaga products are Interchangeable if replacement of the first product with the second product in a system results in comparable photometric and dimming properties of that system.
LED Array	A light source that is supplied as a single unit and intended to be used in combination with a Holder. In addition to one or more LEDs, their mechanical support and their electrical connection, it may contain components to improve its photometric, thermal, mechanical and electrical properties, but it does not include the Electronic Control Gear.
LED Light Engine	A combination of one Electronic Control Gear and one or more LED Modules and means for interconnecting these components. A LED Light Engine may consist of multiple housings.
LED Module	A light source that is supplied as a single unit. In addition to one or more LEDs, their mechanical support and their electrical connection, it may contain components to improve its photometric, thermal, mechanical and electrical properties, but it does not include the Electronic Control Gear.
Light Emitting Surface	A surface of a LLE, LED Module or LED Array with specific dimensions, position and orientation through which the light is emitted.
Luminaire	A lighting fixture which provides an appropriate environment for one or more LLEs and possibly other components.
Luminaire Optics	Set of one or more optical elements, which shape the light output of the LLE, not being part of the LLE itself.
Measurement Uncertainty	Measurement Uncertainty is the same as "expanded uncertainty" as defined in [NIST TN 1297].
Optics Contact Area	Physical surface in the LLE or LED Module with a defined shape and position which allows for a stable and functional positioning of the Luminaire Optics on the LLE or LED Module.
Product Data Set	The combined data in the product data sheet, product label and other public documents related to the product.
Rated <parameter>	The value of the <parameter> as listed in the Product Data Set. Examples: the Rated voltage, the Rated frequency, etcetera.
Rated Operating Temperature	Value of the operating temperature (t_r *or* t_p) at which the Rated LLE, LED Module or LED Array values are specified.
Reference Temperature	The temperature at a specified position on the Thermal Interface Surface under steady state operating conditions.

	The exact coordinates of this position are defined for each type of LLE or LED Module in the respective Book.
Relative Partial Luminous Flux	Percentage of the luminous flux that is emitted by a light source into the rotationally symmetric solid angle bounded by two polar angles (see also section 4.4).
Separate ECG	An ECG of an LLE that is accommodated in a housing that is separate from the LED module(s) of the LLE.
Test Engine	A device that is used to define and measure properties of a Luminaire.
Test Fixture	A device that is used to define and measure properties of a LED Light Engine, a LED Module or a LED Array.
Thermal Interface Material	Material at the Thermal Interface Surface which has the purpose to improve the heat transfer from the LLE, LED Module or LED Array to the heat sink of the Luminaire.
Thermal Interface Surface	The surface of the LLE, LED Module, LED Array or Thermal Test Engine that makes physical contact with the surface of the heat sink of the Luminaire.
Zhaga Consumer Product.	A Zhaga Consumer Product is intended to be applied and replaced by consumers.
Zhaga Professional Product	A Zhaga Professional Product is intended to be applied by a Luminaire maker.

1.5 Common acronyms

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

1.6 Common symbols

P_{el}	Electrical power consumed by the LLE (unit: W).
$P_{el,mod}$	Electrical power consumed by the LED Array or LED Module (unit: W).
P_{vis}	Radiant flux of the LLE, LED module or LED Array in the wavelength range from 380 nm up to 780 nm (unit: W).
P_{th}	Thermal power generated in the LLE, LED Module or LED Array (unit: W).

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

$P_{\text{th,front}}$ 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).

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

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

$R_{\text{sp}}^{\text{max}}$ 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.

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

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

$t_{\text{p,rated}}$ 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.

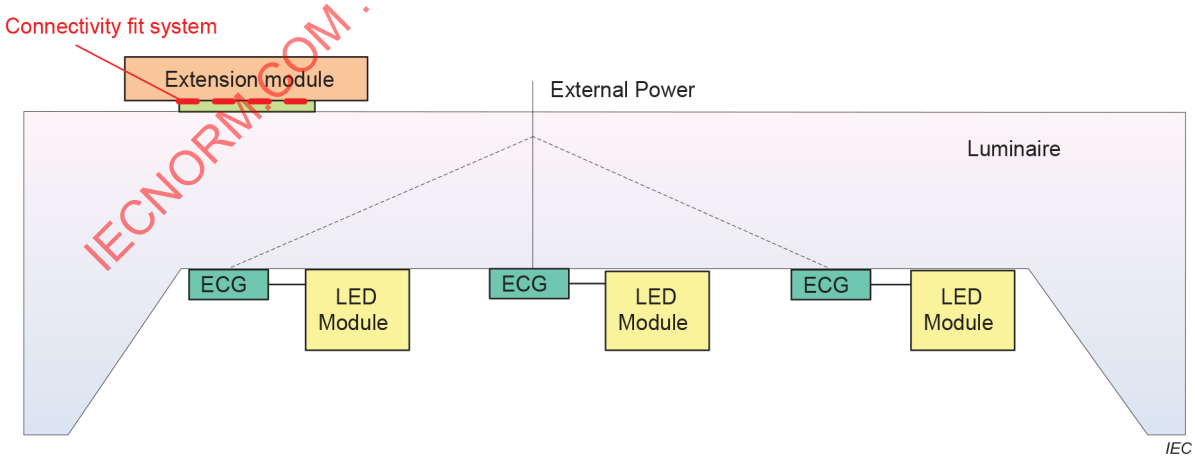


Figure 2-1 – Schematic overview of a Luminaire and one or more non-integrated LED Light Engines

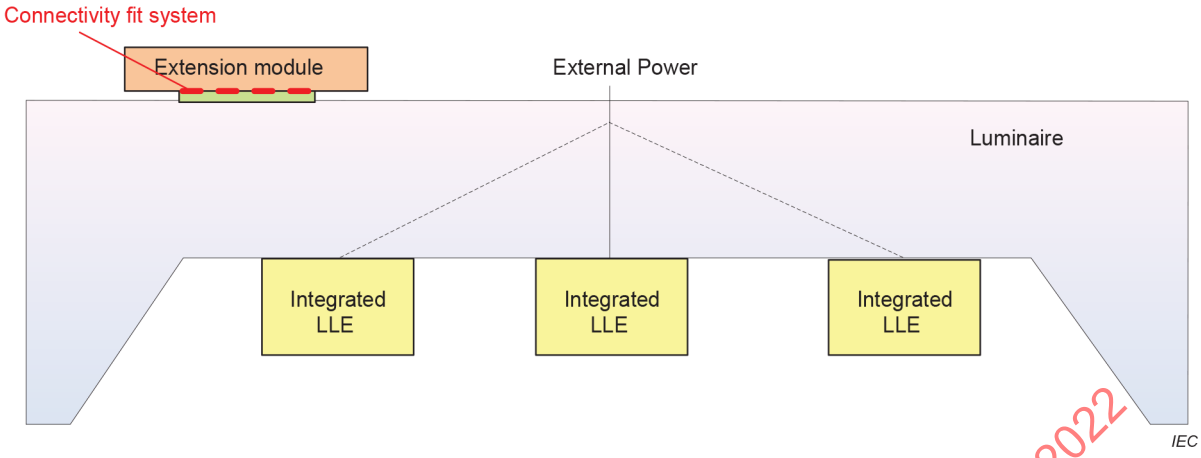


Figure 2-2 – Schematic overview of a Luminaire and one or more integrated LED Light Engines

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.

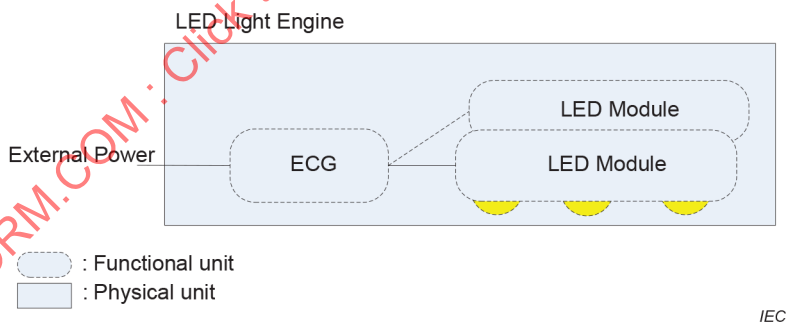


Figure 2-3 – Schematic overview of a LED Light Engine with Integrated ECG

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.

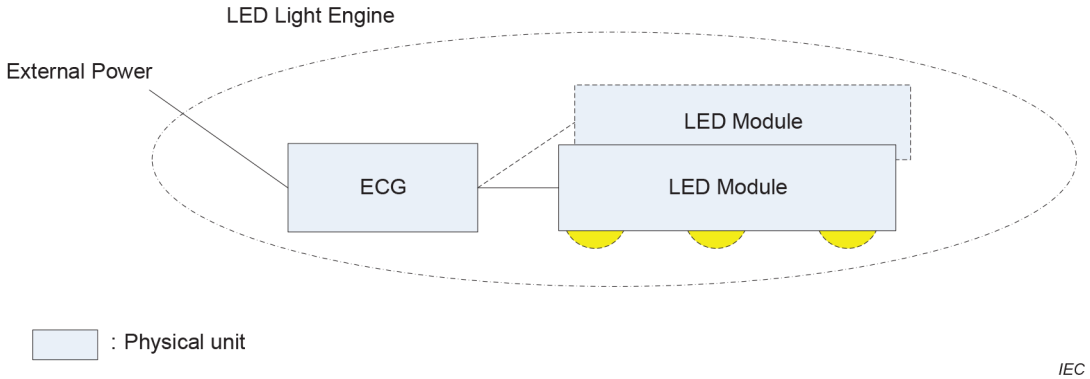


Figure 2-4 – Schematic overview of a LED Light Engine with Separate ECG

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

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

2.5 Compliance testing

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

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

2.5.1 Certification

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

- Next to measurements and tests that may be required for internal purposes and regulations, the manufacturer of a Zhaga product performs all measurements that are needed to

generate the Product Data Set that is required by the Zhaga interface specification. The measurements are performed as defined in the Zhaga interface specification. The outcome of these tests is laid out in the Product Data Set that is provided with the product.

- The manufacturer sends the product with associated Product Data Set to an Authorized Testing Center. The ATC performs all compliance tests that are listed in the corresponding Zhaga book and returns a test report and a test report summary to the manufacturer.
- The manufacturer sends the test report summary to the Zhaga Logo License Administrator. If the test report summary indicates that the product has passed all tests, the Zhaga Logo License Administrator certifies the product.

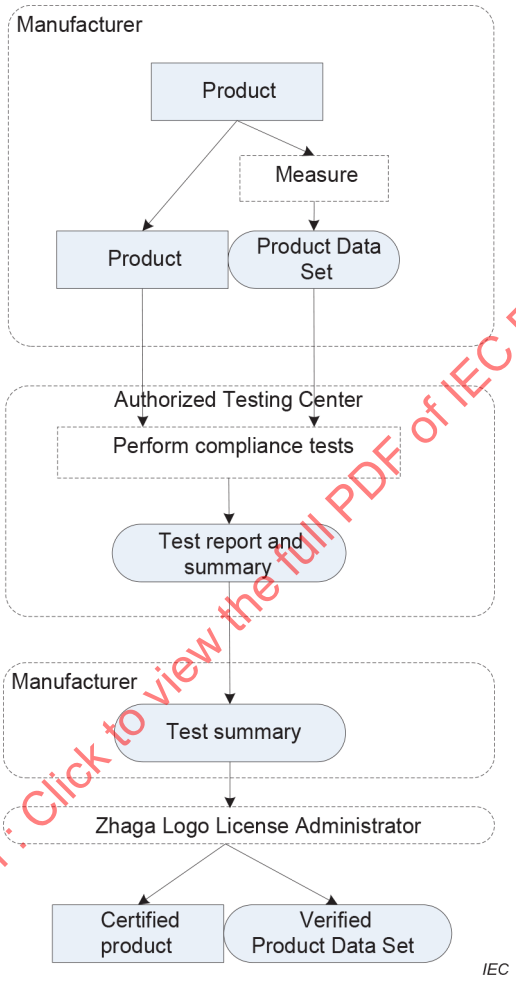


Figure 2-5 – Overview of test and certification of Zhaga products

2.5.2 Market surveillance

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

2.6 Compatibility check

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

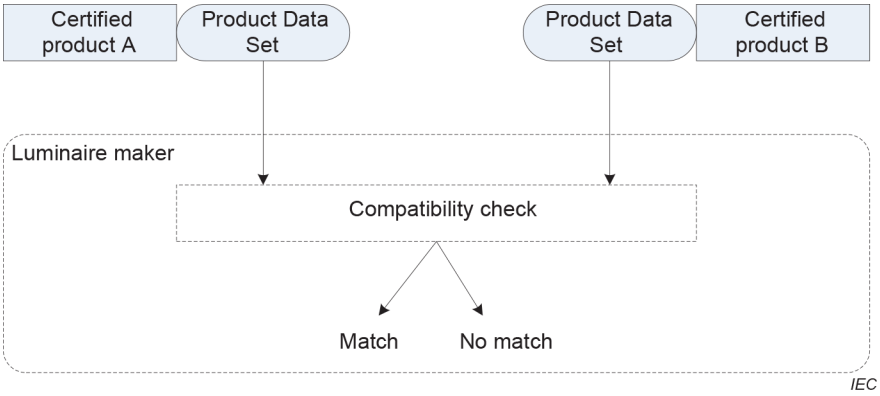


Figure 2-6 – Compatibility check

2.7 Zhaga product certification

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

3 Mechanical interface

3.1 Drawing principles

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

- The dimensions are in millimeters.
- The minimum and maximum values provided in tables that accompany the drawings represent absolute limits, without any implied tolerance (neither positive, nor negative).
- Typical values as well as values between parentheses are informative.

3.2 Mechanical interface between Separate ECG and Luminaire

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

3.3 Thermal expansion

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

3.4 Demarcation (Informative)

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

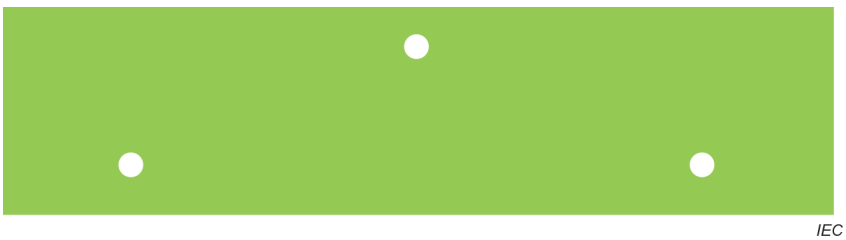


Figure 3-1 – Example of a Demarcation Model (2-dimensional)

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

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

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

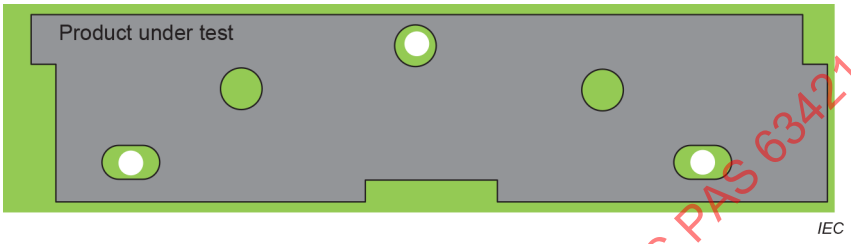


Figure 3-2 – Example of a product which is compliant with the Demarcation Model

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

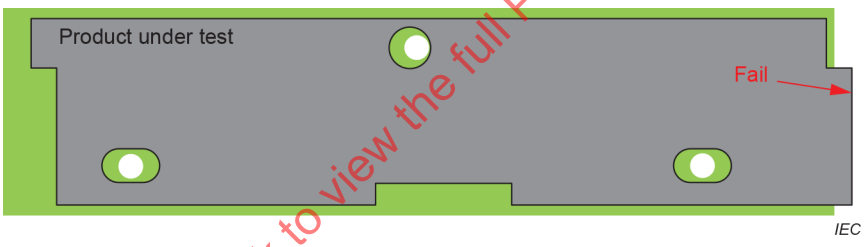


Figure 3-3 – Example of a product which is not compliant with the Demarcation Model

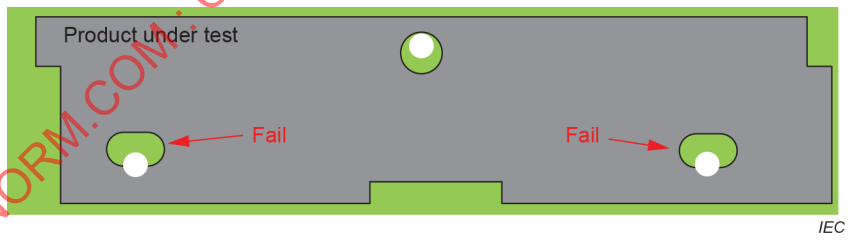


Figure 3-4 – Example of a product which is not compliant with the Demarcation Model

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

4 Photometric interface

4.1 Light Emitting Surface

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

- All substantial light generated by the LED Light Engine or the LED Module/LED Array is emitted through this surface.
- The center of the Light Emitting Surface coincides with the reference point of the luminous intensity distribution (See Figure 4-1).

- The LES is generally described by simple a geometrical shape, for example a circle or a rectangle. It has a physical boundary or is a virtual surface in the surrounding area of the LLE or the LED Module/LED Array.

(Informative)

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

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

Examples LES definitions:

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

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

4.1.1 LES categories

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

Table 4-1 – Definition of circular LES categories

LES category designation	Minimum LES diameter[4]	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:

4 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 LED Module/LED Array shall be mounted in Test Fixture PETF according to the manufacturer's mounting instructions.
- The LED Module/LED Array shall be connected to a power source according to the manufacturer's instructions. The input current and voltage shall be within 0,2% of the Rated values.
- The ambient temperature shall be stable within the range 25 ± 1 ℃.
- The heat sink of the test fixture shall maintain the temperature t_r *or* t_p within the range $t_{r,rated} \pm 1$ ℃ or $t_{p,rated} \pm 1$ ℃ respectively.
- The photometric output of the 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 & 277 VAC

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

4.3 Luminous flux

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 γ_1 and γ_2, as shown in Figure 4-1.

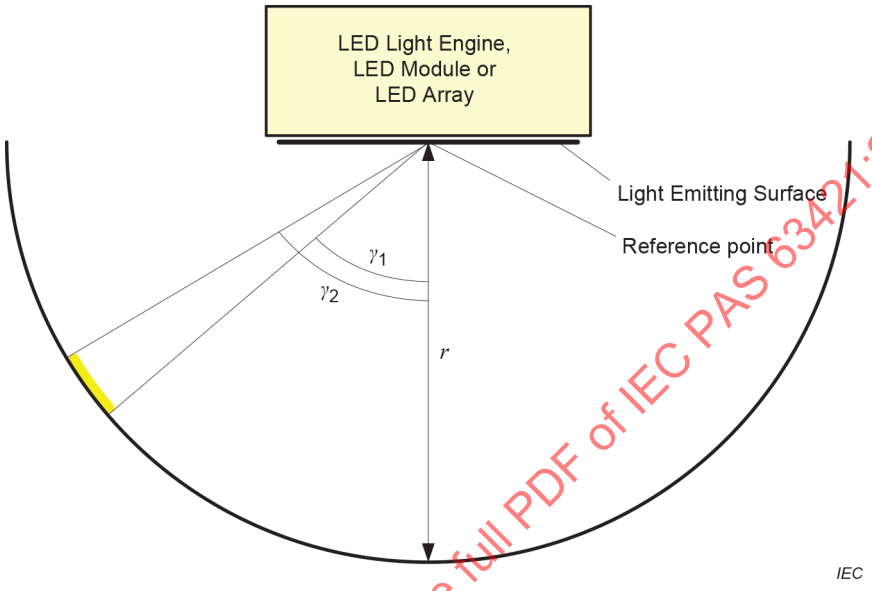


Figure 4-1 – Rotationally symmetric solid angle bounded by the polar angles γ_1 and γ_2 which is used to define the Relative Partial Luminous Flux

4.4.1 Beam angle and beam angle categories

The beam angle shall be defined as in [IEC TR 61341:2010] and the beam angle categories shall be defined as in Table 4-3.

Table 4-3 – Definition of beam angle categories

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

4.5 Luminance uniformity

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

4.6 Correlated color temperature (CCT)

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

4.7 Color rendering index (CRI)

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

4.8 Luminaire Optics (informative)

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

5 Electrical interface

5.1 Electrical insulation (informative)

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

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

6 Thermal interface

6.1 Background information (informative)

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

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

6.2 Generic thermal interface model

6.2.1 General case

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

1) A LLE with Integrated ECG. In this case the thermal interface is defined as the contact surface of the LLE and the Luminaire.
2) A LED Module. In this case the thermal interface is defined as the contact surface of the LED Module and the Luminaire.
3) A LLE with Separate ECG. In this case the thermal interface is defined as the contact surface of the LED Module and the heat sink 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.

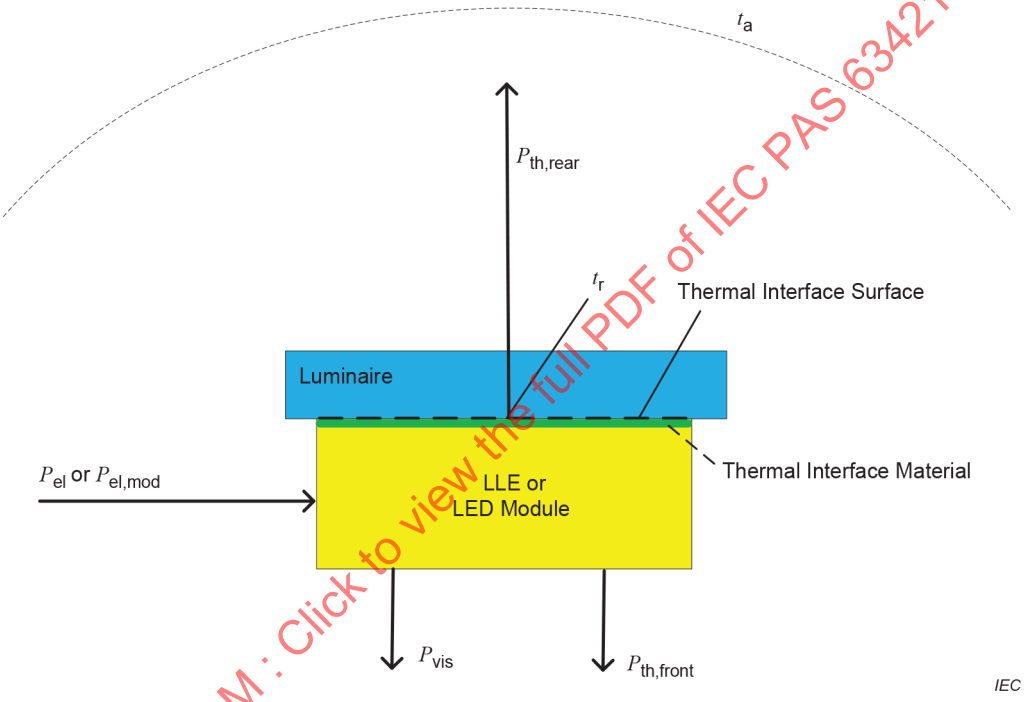


Figure 6-1 – Thermal model of a LLE – Luminaire or a LED Module – Luminaire combination

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:

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

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 nm< λ < 780 nm)[5].

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

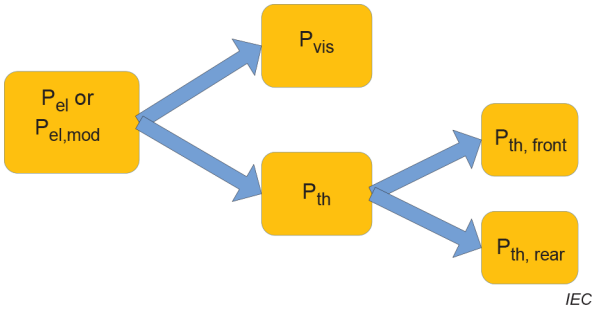


Figure 6-2 – Power conversion

Some of the thermal power P_{th} is drained by convection and infra-red radiation. The sum of the thermal power drained by convection and IR radiation is denoted by $P_{\mathrm{th,front}}$[6]. Typically a substantial part of the thermal power will be drained through the Thermal Interface Surface to the heat sink of the Luminaire[7]. This portion is denoted by $P_{\mathrm{th,\,rear}}$.

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

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

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

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

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

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

6.2.2 Test Fixture TPTF

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

6 $P_{\mathrm{th,front}}$ 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.

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

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

6.2.3 Rated Operating Temperature and safety (informative)

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

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

6.2.4 Thermal overload protection (Informative)

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

6.2.5 Ambient Temperature

As indicated in EQ. 6-5, the maximum thermal resistance of the LLE or LED Module ($R_{\mathrm{th,max}}$) depends on the Ambient Temperature. With increasing Ambient Temperature $R_{\mathrm{th,max}}$ 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 $R_{\mathrm{th,max}}$ for several values of the Ambient Temperature. For each type of LLE or LED Module, Product Data Set requirements with respect to $R_{\mathrm{th,max}}$ 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 $R_{\mathrm{th,max}}$ 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 $R_{\mathrm{th,max}}$ 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[9]. For such systems, the thermal resistance of the Luminaire is defined as:

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

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

$P_{\mathrm{th,rear}}$: 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 ($P_{\mathrm{th,rear}}$). For that reason several values of $P_{\mathrm{th,rear}}$ and corresponding values of R_{th} are listed on the Product Data Set of the Luminaire.

In order to determine whether a particular LLE or LED Module is thermally compatible[10] 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 $R_{\mathrm{th,max}}$ 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 $R_{\mathrm{th,max}}$ 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:

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

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

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

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

From these numbers it can be concluded that

9 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.

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

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

6.2.8 Thermal uniformity

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

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

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

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

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

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

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.