

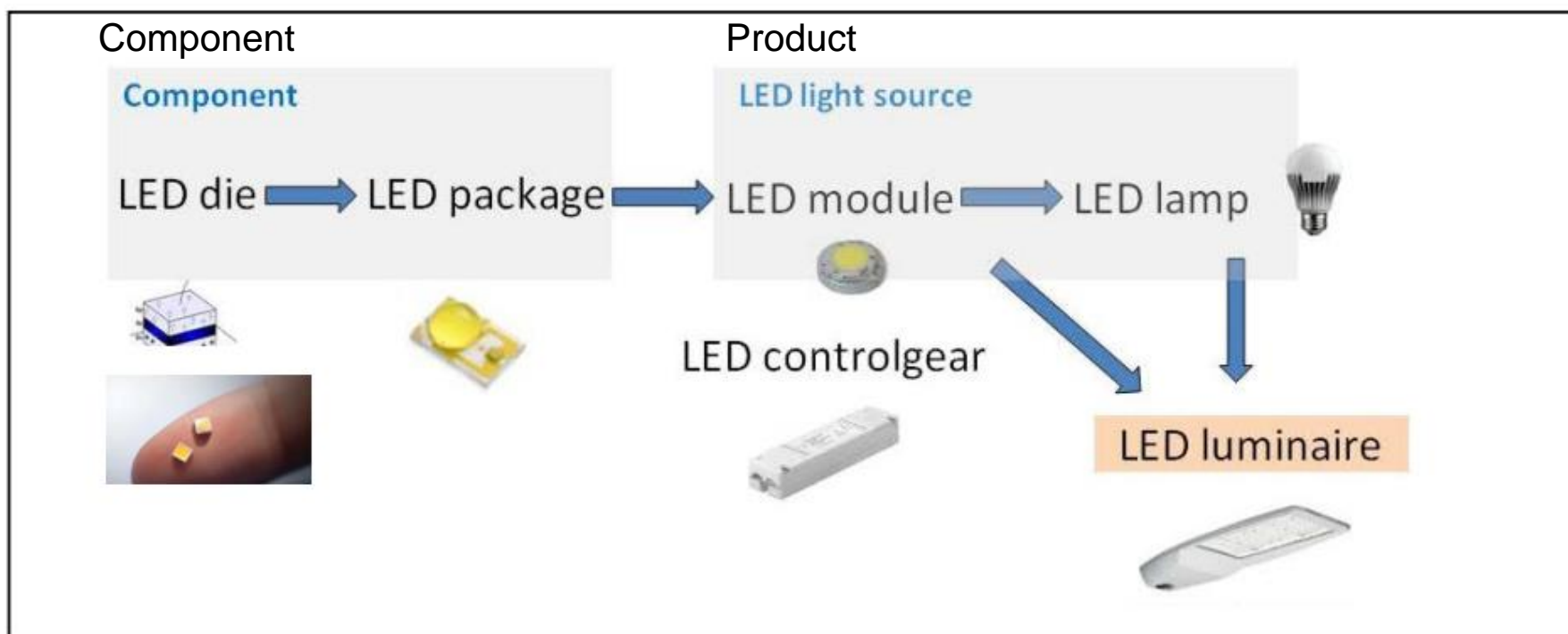
Overview of LED standards related to lifetime and reliability testing

Content

1. LED Product Levels and Terminology
 2. LED Products: The Standardization Landscape
 3. LED Lifetime and Reliability - Automotive Specific Standards
 4. LED Lifetime and Reliability - General Illumination / non-Automotive
 5. Overview of relevant Lighting Committees
 6. Summary / Conclusions
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LED Product Levels and Terminology

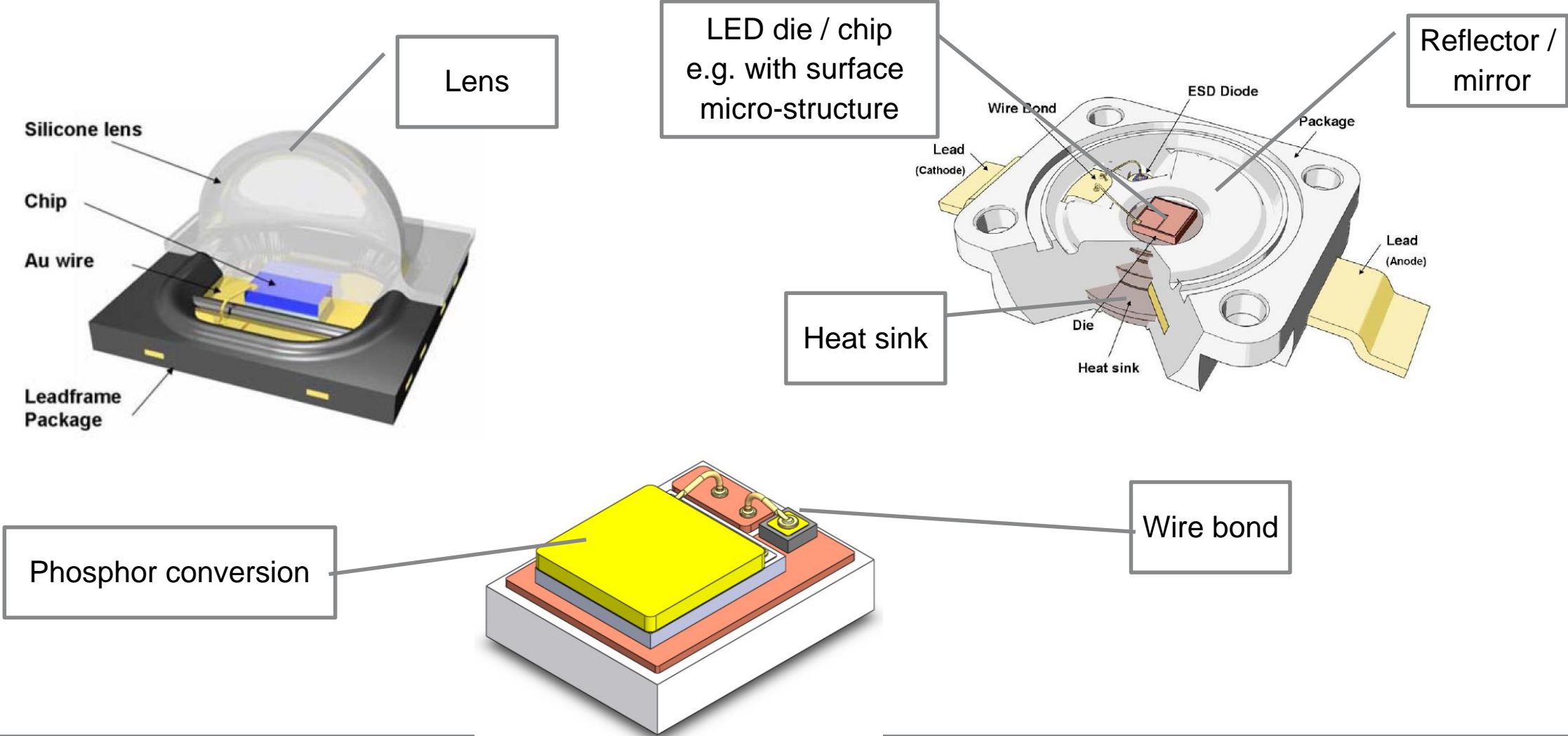
IEC 62504:2014: General lighting - Light emitting diode (LED) products and related equipment - Terms and definitions



IEC 1874/14

Figure A.8 – LED product tree overview

Examples for LED packages and key components for reliability



The LED Standardization Landscape 1/2

“Vertical” standards for Safety and Performance for LED products

LED Product	Safety Standard	Performance Standard
LED luminaire	IEC 60598 series	IEC 62722-2-1:2014
LEDi lamp	IEC 62560:2015	IEC 62612:2015
LEDsi lamp	IEC 62838:2015	In preparation
LEDni lamp	In preparation	In preparation
LEDsi-linear lamp	IEC 62776:2015	In preparation
LEDi-linear lamp	In preparation	In preparation
LED module	IEC 62031:2014	IEC 62717:2015
OLED	IEC 62868:2014	IEC 62922:2015
LED package	-	In preparation at IEC
Automotive Light Sources	IEC 60809	IEC 60810
LED package	-	ANSI C78.374-2015
LED products	UL 8750	

Reliability and lifetime is addressed here

i = integrated
si = semi-integrated
ni = not integrated

The LED Standardization Landscape 2/2

“Horizontal” standards covered in IEC

Topic	LED Luminaire	LED Lamp/module	LED package
Terminology	X	X	X
EMC / EMF	X	X	-
Insulation Coordination	X	X	X
Photobiological safety	X	X	X
Reliability	X	X	X
Binning / colour groups	X	X	X
etc			

General Reliability Test Standards, which may be applied to LED

Standard	Title	Comment
IEC 62506	Methods for product accelerated testing	Generally applicable, but not specific for semiconductors or LEDs
...		
Q101	Stress Test Qualification for Discrete Semiconductors	Applicable to discrete semiconductors, but not specific for LEDs
...		

LED Lifetime and Reliability - Automotive Specific Standards 1/2

Standard	Title	Comment
IEC 60810:2014 Edition 4	Lamps for road vehicles – Performance requirements	This standard includes test requirements for LED light sources and qualification testing of LED packages (see next slides)
IEC 60810:[2017] Edition 5 (current status: positive CDV)	Lamps, light sources and LED packages for road vehicles – Performance requirements	Update of LED package qualification testing and introduction of an LED package robustness validation guideline (see next slides)
ZVEI PCN Guideline	Guideline for Customer Notifications of Product and /or Process Changes (PCN) of Electronic Components specified for Automotive Applications	Reference is made from IEC60810:[2017] to this ZVEI PCN Guideline

LED Lifetime and Reliability - Automotive Specific Standards 2/2

Standard	Title	Comment
SAE/USCAR 33:2013	Specification for Testing Automotive LED Modules	Test requirements for LED modules and LED package over-stress tests (see back-up slides)
SAE J2938:2012 SAE J2938:[2017]	LED Light Sources Tests and Requirements Standard	Referencing LM80 and TM-21; Update in preparation, with reference to IEC60810 qualification testing
SAE J3014:2013	Highly Accelerated Failure Test (HAFT) for Automotive Lamps with LED Assembly	(see back-up slides)
(AEC Q102)	Failure Mechanism Based Stress Test Qualification for Discrete Optoelectronic Semiconductors in Automotive Applications	In preparation

- 7 Requirements and test conditions for LED light sources
 - 7.1 Basic function and interchangeability
 - 7.2 UV radiation
 - 7.3 Luminous flux and colour maintenance
 - 7.4 Resistance to vibration and shock
 - 7.5 Electromagnetic compatibility
 - 7.6 Powered thermal cycling test

Annex I Luminous flux maintenance test conditions for LED light sources

- 8 Requirements and test conditions for LED packages
- 8.1 LED package stress test qualification
- 8.2 Test samples
- 8.3 Definition of failure criteria
- 8.4 Choice between test conditions
- 8.5 Criteria for passing qualification/requalification

8.6 Qualification test definition

8.6.1 Pre- and post- electrical and photometric test

8.6.2 Pre- and post- external visual (EV) test

8.6.3 High temperature operating life (HTOL) test

8.6.4 Temperature cycling (TMCL) test

8.6.5 Wet high temperature operating life (WHTOL) test

8.6.6 Power temperature cycling (PTMCL) test

8.6.7 Electrostatic discharge, human body model (ESD-HBM) test

8.6.8 Electrostatic discharge, machine model (ESD-MM) test

8.6.9 Destructive physical analysis (DPA) test

8.6.10 Physical dimensions (PD) test

8.6.11 Vibrations variable frequency (VVF) test

8.6.12 Mechanical shock (MS) test

8.6.13 Resistance to soldering heat (RSH-TTW) test

8.6.14 Resistance to soldering heat (RSH-reflow) test

8.6.15 Solderability (SO) test

8.6.16 Thermal shock (TMSK) test

8.6.17 Hydrogen sulphide (H₂S) test

8.6.18 Pulsed operating life (PLT) test

8.6.19 Dew (DEW) test

8.6.20 Flowing mixed gas corrosion (FMGC) test

Annex J Destructive physical analysis for LED packages

Annex K Communication sheet LED package testing

Annex L Re-testing matrix for LED package testing

Additions to clause 7 for LED light sources

7.8 Typical circuits for LED light sources

7.8.1 Introduction

7.8.2 Typical circuits for LR3, LR5, LY3, LY5, LW3 and LW5 LED light sources

7.8.3 Typical circuits for LR4 LED light sources

7.9 Typical circuits for LED light sources

7.10 Overvoltage Test

7.11 Reverse Voltage Test

7.12 Transient Voltage Test (Field Decay)

7.13 Transient Voltage Test (Load Dump)

7.14 Electrostatic Discharge Test (ESD)

7.15 Pulsed operating Life (PLT) Test

Additions to clause 8 for LED package qualification

8.6.21 Wire bond strength test (WBS)

8.6.22 Bond shear test (BS)

8.6.23 Die shear test (DS)

Annex L Re-testing matrix for LED package testing

Reference to ZVEI Guideline

New Annex M: Guideline on LED packages Robustness Validation

M.1 General

M.2 Test samples

M.3 Definition of end-of-test criteria

M.4 Test sequence of over-stress testing

M.5 Over-stress test definition

M.5.1 Pre- and post- electrical and photometric test

M.5.2 Pre- and post- external visual (EV) test

M.5.3 High temperature operating life (HTOL) and Low temperature operating life (LTOL) tests

M.5.4 Temperature cycling (TMCL) test

M.5.5 Wet high temperature operating life (WHTOL) test

M.5.6 Power temperature cycling (PTMCL) test

M.5.7 Thermal shock (TMSK) test

M.6 Destructive physical analysis (DPA) test

M.7 Projection Models

Standards specific to LED lifetime and Reliability

General illumination, Non-Automotive

Standard	Title	Comment
LM-80:2015	IES Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules	Testing for minimum 6000h at minimum 2 temperatures
TM-21:2011	Projecting Long Term Lumen Maintenance of LED Light Sources	Projection by Exponential Fit Function
TM-26-15	Methods for projecting catastrophic failure rates of LED packages	Weibull-Model FIT-projection
IEC TS 62861:2017	Guide to principal component reliability testing for LED light sources and LED luminaires	See back-up slides
IEC 63013:[2017]	LED packages – Long term luminous and radiant flux maintenance projection	Based on LM80 and TM-21. Publication in preparation, see back-up slides

Committees relevant to LED Lighting standardisation

Committee	Scope	
IEC TC34	All lighting products	International (see next page)
GTB	Automotive lighting only	International (see next page)
SAE	Automotive only	USA / international (see next page)
SAE/USCAR	Automotive only	USA (OEMs)
UL	General lighting	USA
IES	General lighting	USA

IEC TC 34 for “Lamps and related Equipment” is structured in different subcommittees (SC), where SC 34A represents light sources and the **SC34A/WG2** is specific for **automotive light sources**

SC 34A Lamps Members:

- Europe (25 countries)
- Australia
- Brazil
- China
- India
- Iran
- Japan
- Korea
- Malaysia
- New Zealand
- Pakistan
- Russia
- Thailand
- Ukraine
- USA
- South Africa
-

<http://www.iec.ch/>

GTB - The International Automotive Lighting and Light Signaling Expert Group (Groupe de Travail "Bruxelles 1952")

The GTB/WG Light Sources (WGLS) is specific for **automotive light sources**

Automotive Lighting Experts

- Vehicle manufacturers
- Tier 1 (set makers)
- Tier 2 (light source makers)
- Tier 3 (component, material suppliers)
- Test laboratories
- Universities

Countries

- Europe (14 countries)
- USA
- Japan
- China
- Taiwan
- Korea

<http://www.gtb-lighting.org/>

GTB has a liaison agreement with IEC SC34A and SC34B for light source topics

SAE International

The ultimate knowledge source for mobility engineering.



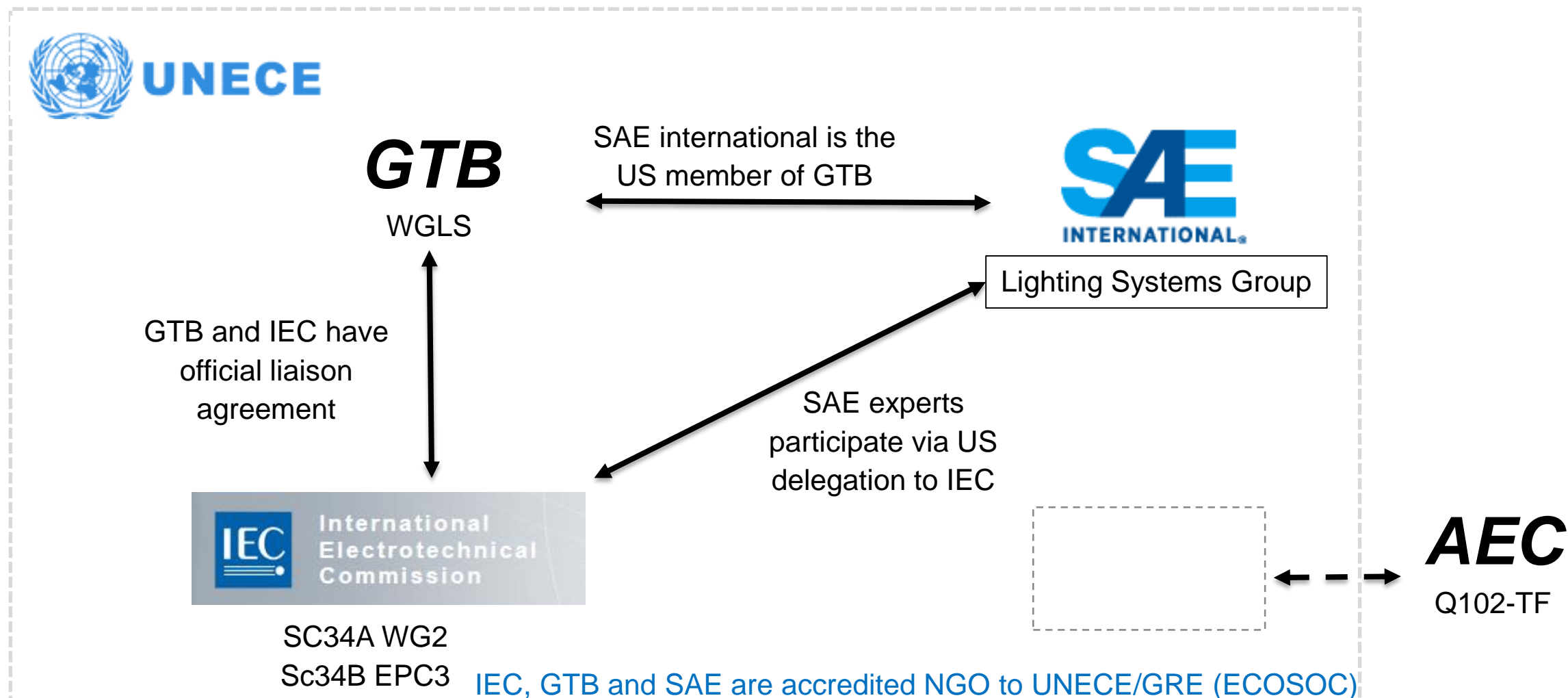
Automotive, Aerospace, Commercial vehicles
SAE is US based

Lighting Systems Committee

- Vehicle manufacturers
- Tier 1 (set makers)
- Tier 2 (light source makers)
- Tier 3 (component, material suppliers)
- Test laboratories
- Universities

<http://www.sae.org>

Working Relationship between Automotive Lighting Organisations



Summary – LED reliability standards - Automotive

	Initial Qualification Testing	Accelerated Stress Testing	Lifetime (lumen maintenance) testing/ projection
LED package	IEC 60810 (Q102)	IEC 60810 USCAR-33	SAE J2938
LED module	IEC 60810 USCAR-33	USCAR-33 SAE J3014	IEC 60810
LED luminaire	??	SAE J3014	??
Laser-diode package	(IEC 60810) (Q102)	??	??
OLED	(IEC 60810)	??	(IEC 60810)
Laser-based modules	(IEC60810) (Q102)	??	(IEC 60810)
Photodiodes / Phototransistors	(Q102)	??	??

Summary – LED reliability standards – General Lighting (non-automotive)

	Initial Qualification Testing	Accelerated Stress Testing	Lumen maintenance testing/ projection
LED package	IEC TS 62861	IEC TS 62861	LM80 TM-21 (IEC 63013)
LED module	IEC 62717	IEC TS 62861	IEC 62717
LED luminaire	IEC 62722-2-1	IEC TS 62861	IEC 62722-2-1

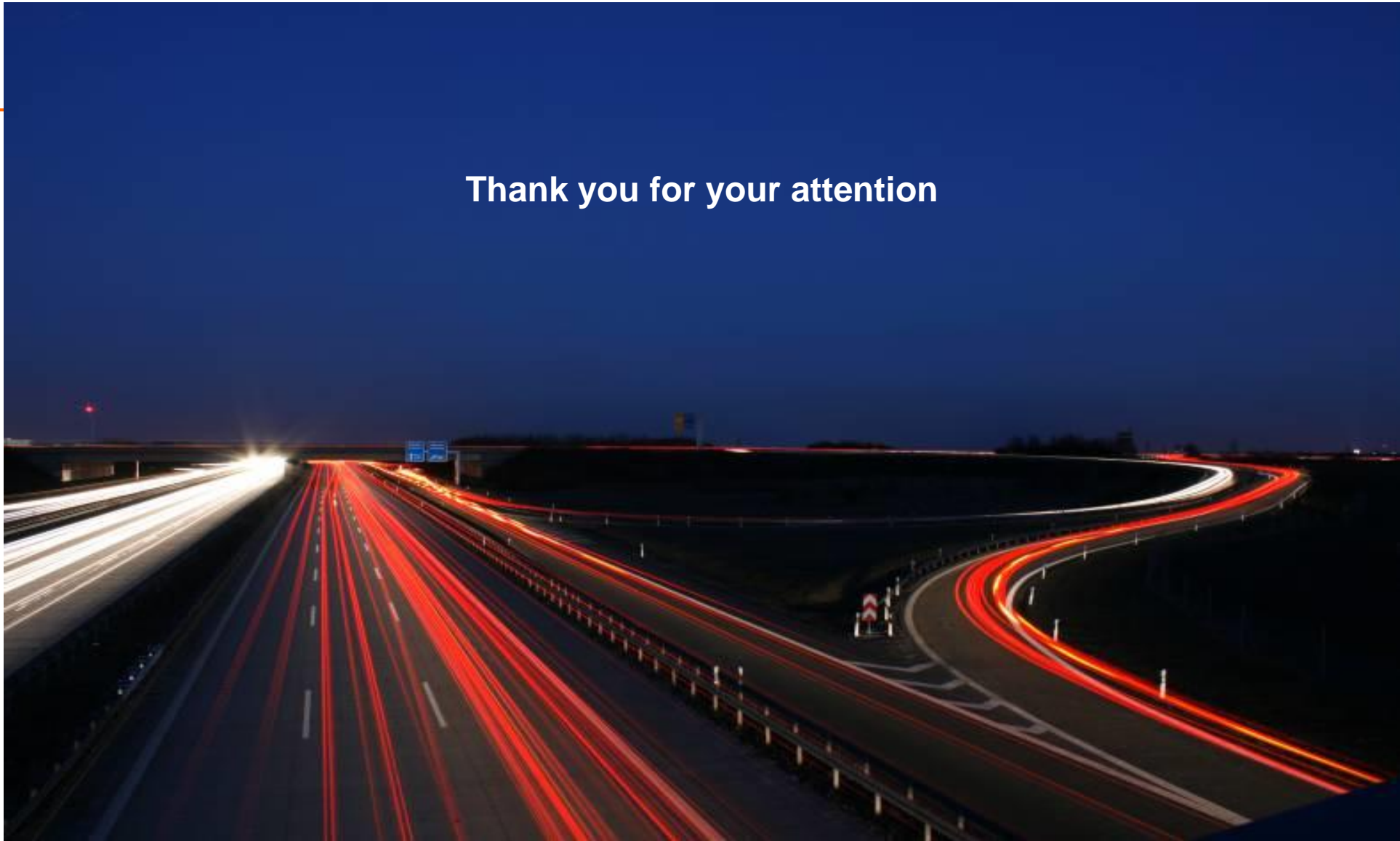
CONCLUSIONS

- There is a wide range of specific standards available for LED lighting products and components
- There is a network between the different automotive lighting expert groups to have alignment in the efforts
- Several existing standards address specifically the reliability of LED products
- There are some gaps that need to be filled in the near future, e.g. for upcoming innovations
- The industry is interested to avoid conflicting standards

- We, the global LED lighting community, must have a detailed look at existing standards, identify gaps, and jointly work together to close these gaps with relevant standards
- Photodiodes / Phototransistors are currently not addressed by GTB, SAE or IEC TC34

We should set-up a global round-table meeting with all stakeholders to discuss the way forward

Thank you for your attention



Back-Up Slides

SAE/USCAR 33:2013

SPECIFICATION FOR TESTING AUTOMOTIVE LED MODULES 1/3

SCOPE

This specification is a general level subsystem light source specification that establishes test requirements of Light Emitting Diode (LED) components and modules for use in automotive lighting systems.

The completed test data to this test specification is intended to be provided to the OEM by the Tier I lamp set maker as part of the lamp assembly PPAP. Re-testing shall be required if any portion of the approved LED modules experiences a design, manufacturing or component change.

This document shall be applied to systems that meet the requirements for design, performance and validation established by government standards.

The LED module is defined as the LED devices and any electronics required to properly energize the LEDs using vehicle electrical power system along with any associated electrical wiring, connectors and thermal management system. Samples shall be tested as a subsystem and considered one test sample for the entire test sequence. A failure of any component in the test sample shall constitute a failure of the entire sample. *If other manufactures components are intended to be approved for use in the LED modules, then those possible combinations of components shall be considered a new LED module and shall also be tested.*

Additional testing may be required by individual OEM's to meet specific EMC, quality, reliability and durability objectives.

The following tests are to be performed under the following conditions:

- New sample
- Design or process change made to an existing module
- Completion of one calendar year as noted in the "ANNUAL TESTS" Table shown in the Appendix.

(Note: Production process control data, collected at a shorter interval per an approved control plan, may be substituted if approved by customer's responsible engineer and purchasing representative.)

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- 1. SCOPE
 - 2. SAFETY PRECAUTIONS
 - 3. REFERENCE STANDARDS
 - 4. DIAGRAMS AND DEFINITIONS
 - 4.1 APPENDICES
 - 5. GENERAL REQUIREMENTS
 - 5.1 RECORD RETENTION
 - 5.2 SAMPLE DOCUMENTATION AND RETENTION
 - 5.3 POWER SOURCES
 - 5.4 EQUIPMENT TOLERANCES
 - 5.5 MEASUREMENT ACCURACY
 - 5.6 TEST REPEATABILITY AND CALIBRATION
 - 5.7 TEST DEFAULT CONDITIONS
 - 5.8 TEST SHARING WITHIN LIGHT SOURCE FAMILIES
 - 5.9 TEST FAILURE PROCEDURE
 - 5.10 CONTROL PLANS
 - 5.11 RELIABILITY PROGRAMS AND METHODS
 - 5.12 HAZARDOUS MATERIAL RESTRICTION
 - 5.13 DOCUMENTATION
 - 6. ANALYSIS
 - 7. LED MODULE COMPONENTS
 - 7.1 MODULE COMPONENTS
 - 7.2 LUMEN / CHROMATICITY MAINTENANCE
 - 7.3 LED BINNING
 - 7.4 LED OVERSTRESS TESTING
 - 8. LED MODULE ASSEMBLY TESTING
 - TEST SAMPLES
 - ENVIRONMENTAL CONDITIONS
 - 8.1 TEMPERATURE SOAK
 - 8.2 THERMAL SHOCK IN AIR (TS)
 - 8.3 THERMAL SHOCK WATER
 - 8.4 POWER TEMPERATURE CYCLE (PTC) TEST.
 - 8.5 SALT FOG/SPRAY
 - 8.6 HUMIDITY
 - 8.7 ALTITUDE
 - 8.8 DUST
 - 8.9 WATER SPRAY
 - 8.10 FLUID RESISTANCE
 - 8.11 OUTGASSING

9. MECHANICAL

9.1 STEADY STATE LOADS (CRUSH)

9.2 VIBRATION

9.3 MECHANICAL SHOCK

9.4 FREE FALL (DROP)

10. ELECTRICAL

10.1 JUMP START (OVER-VOLTAGE) AND REVERSE POLARITY

10.2 BATTERY VOLTAGE DROPOUT

10.3 SUPERIMPOSED ALTERNATING VOLTAGE

10.4 SHORT CIRCUIT

10.5 OPEN CIRCUIT

10.6 ISOLATION

10.7 INTENTIONALLY LEFT BLANK

10.8 LEAKAGE CURRENT

10.9 LOW POWER

10.10 ELECTROMAGNETIC COMPATIBILITY

10.11 ELECTROSTATIC DISCHARGE

10.12 REDUCED VOLTAGE OPERATION

10.13 STARTING PROFILE

10.14 CONNECTOR TESTS

10.15 LAMP OUTAGE DETECTION

10.16 LIGHT OUTPUT TEMPERATURE COMPENSATION

11. PHOTOMETRICS

11.1 MODULE LUMINOUS INTENSITY MAINTENANCE ANALYSIS

12. END OF LINE TESTING

APPENDIX A: GLOSSARY

APPENDIX B: FLUID SOURCES

APPENDIX C: TEST SEQUENCE

APPENDIX D: DESIGN GUIDELINES

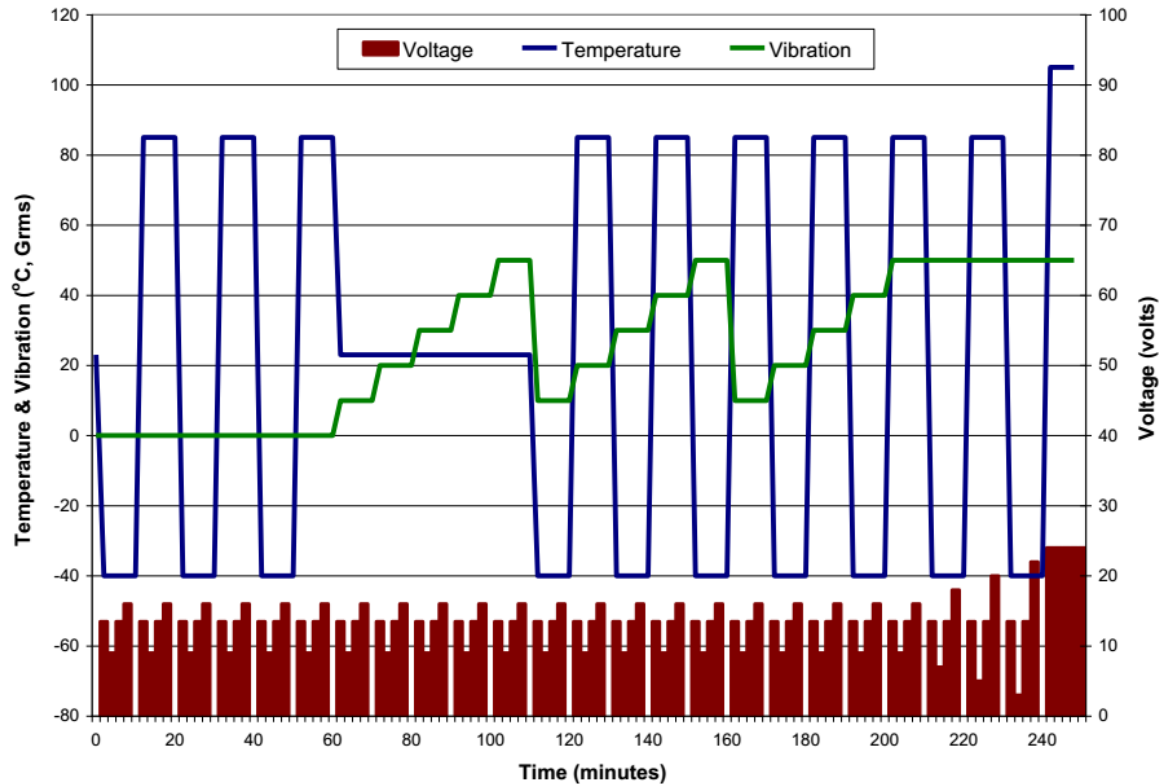
APPENDIX E: ANNUAL TESTS

APPENDIX F: REVISIONS

SAE J3014:2013 Highly Accelerated Failure Test (HAFT) for Automotive Lamps with LED Assembly

1. SCOPE

This SAE Recommended Practice provides test procedures, requirements, and equipment recommendations for the methods of the measurement that characterizes potential design failures by utilizing a step stress approach to subject a device under test to thermal, vibration, and electrical stresses of types and levels beyond what it may see in actual use, but which will rapidly induce failure modes, allowing them to be detected and corrected.



IEC TS 62861:2017 GUIDELINES FOR PRINCIPAL COMPONENT RELIABILITY TESTING FOR LED LIGHT SOURCES AND LED LUMINAIRES

1/3

Scope

This Technical Specification provides guidelines for establishing confidence in product reliability using principal component testing for LED light sources and LED luminaires for general lighting. It includes methods and criteria using initial qualification tests and accelerated stress tests of the principal components. The performance of any principal component will influence the performance of the final product.

Techniques to validate full lifetime claims and lumen maintenance projection are outside the scope of this Technical Specification.

The following principal components are included in the testing if they are used as an integral part for the LED light source or LED luminaire:

- LED package and interconnects;
- optical materials;
- electronic subassemblies;
- cooling systems, both active (e.g. fans) and passive (e.g. thermal interface material);
- construction materials.

This Technical Specification is not recommended for use as a normative reference to the LED product performance standards.

5 LED package and interconnects

5.1 General

5.2 Sampling requirements

5.3 Production requirements

5.4 Assembly of LED packages on test boards

5.5 Moisture preconditioning

5.6 Thermal characteristics

5.7 Pre- and post-stress electrical and photometric requirements

5.8 Pre- and post-stress visual inspection

5.9 Solderability and resistance to soldering heat

5.9.1 Solderability

5.9.2 Resistance to soldering heat (RSH-reflow) test

5.10 Failure criteria

5.11 Initial qualification tests for LED packages

5.11.1 General

5.11.2 Temperature and operation stress

5.11.3 Thermo-mechanical stress

5.11.4 Temperature and humidity stress

5.11.5 Electrical stress – ESD-HBM

5.11.6 Environmental stress

5.12 Initial qualification test for LED package interconnects – VVF

5.13 Accelerated stress tests for LED package interconnects

5.13.1 General

5.13.2 Interconnect temperature cycling (TMCL)

10 Final product testing

10.1 General

10.2 Principal component reliability in the final product

10.3 Minimum validated AST time

10.4 Final product qualification for reliability

Annex A Application profiles

Annex B Acceleration models

(Arrhenius model, Eyring model, Coffin-Manson model, Norris-Landzberg model, (Inverse) power law, Peck model , Generalized Eyring model, Sample size calculation, Basic guidelines, Example)

Annex C System reliability

(General, Basic principles, Testing on the system level, System reliability prediction, General, Block diagrams, Fault tree, Markov chains, Bayesian networks, Chi-square)

Annex D Qualification flowcharts

Annex E Physical analysis for principal components

Annex F Principal component test report

IEC 63013:[2017] LED packages – Long term luminous and radiant flux maintenance projection

1/2

- 1 Scope
- 2 Normative references
- 3 Terms and definitions
- 4 Test method, data collection and sample size
- 5 Long-term luminous flux maintenance projection methods
 - 5.1 General
 - 5.2 Exponential fit function (EFF)
 - 5.2.1 Method
 - 5.2.2 Criteria
 - 5.3 Border function (BF) 8
 - 5.3.1 Method
 - 5.3.2 Criteria
 - 5.3.3 Calculating the test data slope and the BF slope

- 6 Temperature data interpolation
- 7 Adjustment of results
- 8 Reporting

- Annex A (informative) Temperature acceleration
 - A.1 Temperature acceleration – Arrhenius method (TA-A)
 - A.1.1 Method
 - A.1.2 Criteria

Annex B (informative) Process flow chart

Annex C (normative) Border function (BF)

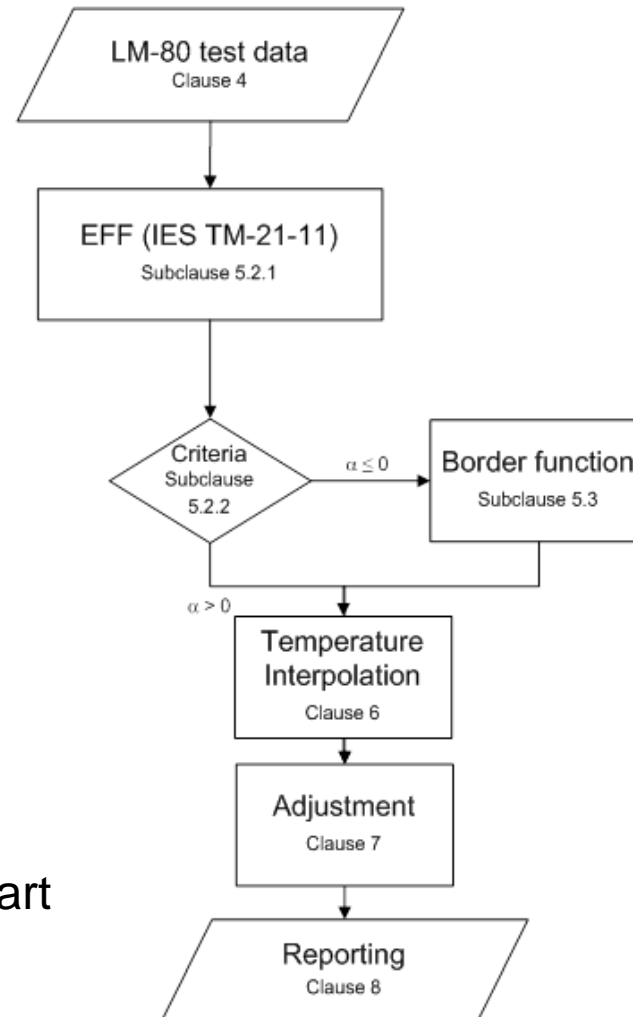


Figure B.1 – Process flow chart