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Guidelines for principal component reliability testing for LED light sources and LED luminaires

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GUIDELINES FOR PRINCIPAL COMPONENT RELIABILITY TESTING FOR LED LIGHT SOURCES AND LED LUMINAIRES

FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62861, which is a Technical Specification, has been prepared by subcommittee 34A: Lamps, of IEC technical committee 34: Lamps and related equipment.

The text of this Technical Specification is based on the following documents:

Enquiry draft	Report on voting
34A/1884/DTS	34A/1966/RVDTS

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

LED products depend generally on how balanced its principal components are in terms of their reliability. It is not only the LED components that determine product performance, but also other parts of the LED product play an equally important role. For instance, electronic subassemblies, optics, mechanics and the involved cooling method play such a role.

This Technical Specification envisions a methodology, which addresses separate subcomponent reliability data, to provide a basis for statistical system reliability design. Standardized reporting formats and flowcharts are presented.

Next, protocols based on accelerated methods are given to estimate system reliability of the final product using subcomponent data.

Verification of LED product lifetime is based on a 'test to pass' principle, which means the components of the product under test are evaluated to give equivalent reliability confidence to that which would be achieved by real-time life testing of the complete LED product. The tests described in this Technical Specification are divided into: initial qualification tests (IQT) giving confidence of basic component robustness, but not linked to any specific lifetime projection, and accelerated stress tests (AST) giving confidence of reliability to a specific lifetime (within the specified constraints of the test).

Since the approach foreseen in this Technical Specification covers a generic methodology, it can be seen as guidance related to relevant product performance standards, such as the LED lamp performance standard IEC 62612, the LED module performance standard IEC 62717 and LED luminaire performance standard IEC 62722-2-1. This Technical Specification is not recommended for use as a normative reference to the LED product performance standards.

This Technical Specification addresses the need for a document giving guidance that is developed according to consensus procedures and in itself is normative in nature, while at the same time recognizing that LED technology for lighting products is still in an emerging phase. This Technical Specification approaches an International standard in terms of detail and completeness.

GUIDELINES FOR PRINCIPAL COMPONENT RELIABILITY TESTING FOR LED LIGHT SOURCES AND LED LUMINAIRES

1 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.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-20:2008, *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

IEC 60068-2-27:2008, *Basic environmental testing procedures – Part 2: Tests – Test Ea and guidance: Shock*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-42:2003, *Environmental testing – Part 2-42: Tests – Test Kc: Sulphur dioxide test for contacts and connections*

IEC 60068-2-43:2003, *Environmental testing – Part 2-43: Tests – Test Kd: Hydrogen sulphide test for contacts and connections*

IEC 60068-2-58:2015, *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60068-2-60:2015, *Environmental testing – Part 2-60: Tests – Test Ke: Flowing mixed gas corrosion test*

IEC 60529:2013, *Degrees of protection provided by enclosures (IP Code)*

IEC 60929:2011, *AC and/or DC-supplied electronic control gear for tubular fluorescent lamps – Performance requirements*
IEC 60929:2011/AMD1:2015

IEC 62504, *General lighting – Light emitting diode (LED) products and related equipment – Terms and definitions*

ANSI/ESDA/JEDEC JS-001-2014, *Electrostatic discharge sensitivity testing human body model (HBM) – Component level*

ASTM D5470 – 12, *Standard test method for thermal transmission properties of thermally conductive electrical insulation materials*

ASTM D7027 – 13, *Standard test method for evaluation of scratch resistance of polymeric coatings and plastics using an instrumented scratch machine*

ASTM E595 – 07, *Standard test method for total mass loss and collected volatile condensable materials from outgassing in a vacuum environment*

IPC-9591, *Performance parameters (mechanical, electrical, environmental and quality/reliability) for air moving devices*

J-STD-002D, *Solderability tests for component leads, terminations, lugs, terminals and wires*

J-STD-020E, *Moisture/reflow sensitivity classification for nonhermetic surface mount devices*

JESD22-A101C, *Steady-state temperature humidity bias life test*

JESD22-A104D, *Temperature cycling*

JESD22-A108D, *Temperature, bias, and operating life*

JESD22-A113F, *Preconditioning of plastic surface mount devices prior to reliability testing*

JESD22-B103B, *Vibration, variable frequency*

JESD51-51, *Implementation of the electrical test method (static test method) for the measurement of the real thermal resistance and impedance of light emitting diodes with exposed cooling surface*

MIL-C-48497A, *Durability requirements for coating, single or multilayer, interference*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62504 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
acceleration factor
AF
ratio of the time it takes for a certain fraction of the population to fail, following application of one stress or use condition, to the corresponding time at a more severe stress or use condition

Note 1 to entry: The failure mode and the type of the failure distribution (lognormal, Weibull, exponential or alike) within the two stress conditions should be identical.

Note 2 to entry: Acceleration factors can be calculated for several stresses that can affect the reliability of the unit under test, such as temperature, electrical, mechanical loads, light exposure, chemical, moisture or other stresses. Annex B presents commonly known acceleration models.

3.2
activation energy
E_a
excess free energy over the ground state that is required in order that a particular process occurs

Note 1 to entry: The activation energy is used in the Arrhenius equation for the thermal acceleration.

3.3
Boltzmann's constant
k_B
constant equal to 1,381 × 10^{-23} J/K or 8,617 × 10^{-5} eV/K

Note 1 to entry: Boltzmann's constant is used in the Arrhenius equation.

3.4
failure mechanism
process that leads to failure

Note 1 to entry: The process may be physical, chemical, logical, or a combination thereof.

[SOURCE: IEC 60050-192:2015, 192-03-12.]

3.5
failure mode
manner in which failure occurs

Note 1 to entry: A failure mode may be defined by the function lost or other state transition that occurred.

[SOURCE: IEC 60050-192:2015, 192-03-17, modified – do not use the wording "DEPRECATED: fault mode".]

3.6
failure rate
probability that a system will fail during the next specified time increment, given that it has survived up to the current point in time

Note 1 to entry: The failure rate of a system usually depends on time, with the rate varying over the lifecycle of the system.

Note 2 to entry: Failure rate is expressed in % failures per time unit.

3.7
application profile
mission profile
user profile
profile describing the environmental loads that are imposed upon the product under normal operation conditions

Note 1 to entry: Annex A presents two example application profiles.

3.8
mean time to failure
MTTF
average period of time for a system to operate without failure

3.9
power factor
ratio of the real power flowing to the load to the apparent power in the circuit

3.10
reliability
<of an item> ability to perform as required, without failure, for a given time interval, under given conditions

Note 1 to entry: The time interval duration may be expressed in units appropriate to the item concerned (e.g. calendar time, operating cycles, distance run) and the units should always be clearly stated.

Note 2 to entry: Given conditions include aspects that affect reliability, such as: mode of operation, stress levels, environmental conditions, and maintenance.

Note 3 to entry: Reliability may be quantified using measures defined in Section 192-05, Reliability related concepts: measures.

[SOURCE: IEC 60050-192:2015, 192-01-24.]

3.11
sample size
representative quantity of units under test extracted from a batch of reference units

3.12
system
set of interacting or interdependent components forming an integrated whole

3.13
system reliability
probability that a system, including all hardware, firmware, and software, will satisfactorily perform the task for which it was designed or intended, for a specified time and in a specified environment

3.14
solder point temperature
t_s
temperature of the point near the LED package interconnect as specified by the manufacturer of the package

3.15
cooling performance
function of a device providing cooling in an amount to maintain the performance of the component to which it pertains

3.16
Weibull distribution
continuous probability distribution described by two parameters: scale parameter α and shape parameter β

3.17
accelerated stress test
AST
test for which a reliability model exists for assessing reliability over a shorter time period than a test under normal application conditions by applying an accelerating stress factor

Note 1 to entry: The reliability model can apply to components and materials.

3.18
initial qualification test
IQT
test to demonstrate a basic level of robustness by applying a non-accelerating stress factor

Note 1 to entry: An IQT is employed when an accelerated reliability model is not appropriate.

3.19
validated AST time
mathematical product of the AST duration used for validation and the acceleration factor

4 Component test conditions

Clauses 5, 6, 7, 8 and 9 specify minimum stress-test driven qualification and reliability requirements for the principal components of LED products. It includes references to test conditions for each component. The purpose is to give guidance for establishing a level of reliability for which a product is specified. What the exact level is depends on the product specification and depends on the application profile. Stress test qualification of the principal components is defined as successful completion of the test requirements outlined in each clause for each principal component. Each clause specifies a set of qualification tests that shall be considered for new LED product qualifications. In case of requalification associated with a design or process change, a limited set of qualification tests may be considered.

This Technical Specification describes two types of qualification tests. A test for which a reliability model exists is called an accelerated stress test (AST) for assessing reliability results over a much shorter test time period. When a reliability model is not appropriate, then the test is termed an initial qualification test (IQT) and used to demonstrate a basic level of robustness. Tests in this Technical Specification are classified as either IQT or AST. The stressors or loads that are imposed upon LED products in two example environmental conditions are described in Annex A. These stressors also apply to the principal components.

NOTE In general, it is assumed that passing the harsher test conditions implies that the more relaxed conditions would also be passed.

For principal components that have failed the acceptance criteria of tests required by this Technical Specification, it is recommended to understand the failure mechanism, determine the root cause and take corrective actions. To confirm that the failure mechanism is understood and contained, and appropriate corrective and preventive actions are effective, it is recommended to repeat the applicable qualification test(s) successfully.

This Technical Specification makes reference to other IEC standards or standards from other organizations. Where relevant, further details on the tests can be found in these documents. Test conditions in this document may deviate from test conditions in the reference documents. In such a case, further specifications in the reference document should still be applied as appropriate.