

SINGAPORE STANDARD
LED modules for general lighting –
Performance requirements

[Identical adoption of IEC 62717:2014]



Published by

Enterprise
Singapore

SS IEC 62717 : 2015
(ICS 29.140.99)

SINGAPORE STANDARD

LED modules for general lighting – Performance requirements

All rights reserved. Unless otherwise specified, no part of this Singapore Standard may be reproduced or utilised in any form or by any means, electronic or mechanical, including photocopying and microfilming, without permission in writing from Enterprise Singapore. Request for permission can be sent to: standards@enterprisesg.gov.sg.

This Singapore Standard was approved by the Electrical and Electronic Standards Committee on behalf of the Singapore Standards Council on 4 December 2015.

First published, 2016

The Electrical and Electronic Standards Committee, appointed by the Standards Council, consists of the following members:

	Name	Capacity
Chairman	: Er. Peter Leong Weng Kwai	<i>Member, Standards Council</i>
Deputy Chairmen	: Mr Cheong Tak Leong Er. Tan Hak Khoo	<i>SPRING Singapore</i> <i>Energy Market Authority</i>
Advisor	: Mr Renny Yeo Ah Kiang	<i>Individual Capacity</i>
Secretary	: Mr Jason Low	<i>SPRING Singapore</i>
Members	: Dr Chua Sze Wey	<i>Agency for Science, Technology and Research</i>
	Assoc Prof Gooi Hoay Beng	<i>Nanyang Technological University</i>
	Er. Hashim Bin Mansoor	<i>Building & Construction Authority</i>
	Assoc Prof Ko Chi Chung	<i>National University of Singapore</i>
	Mr Koh Liang Hock	<i>SP PowerGrid Ltd</i>
	Er. Lim Ah Hee	<i>Housing & Development Board</i>
	Er. Lim Say Leong	<i>Singapore Business Federation</i>
	Er. Ling Shiang Yun / Er. Kenneth Liu	<i>Association of Consulting Engineers Singapore</i>
	Mr Ng Kin Ming	<i>Singapore Electrical Contractors and Licensed Electrical Workers Association</i>
	Er. Ong Ser Huan	<i>Institution of Engineers Singapore</i>
	Mr Sim Geok Seng	<i>SPRING Singapore</i>
	Mr Sim Wee Meng	<i>Land Transport Authority</i>
	Mr Tan Boon Chong	<i>Singapore Manufacturing Federation</i>
	Mr Christopher Tan Eng Kiong	<i>Singapore Civil Defence Force</i>
	Mr Alfred Tan Lai Seng	<i>Singapore Electrical Trades Association</i>
	Dr Timothy Michael Walsh	<i>Solar Energy Research Institute of Singapore</i>
	Mr Justin Wu	<i>National Environment Agency</i>
Co-opted Member	: Mr Chong Weng Hoe	<i>Individual Capacity</i>

The Technical Committee on Building Facilities and Services, appointed by the Electrical and Electronic Standards Committee and responsible for the preparation of this standard, consists of representatives from the following organisations:

	Name	Capacity
Chairman	: Er. Kenneth Liu	<i>Member, Electrical and Electronic Standards Committee</i>
Deputy Chairman	: Er. Hashim Bin Mansoor	<i>Building & Construction Authority</i>
Secretary	: Mr Allan Koh	<i>SPRING Singapore</i>
Members	: Mr Cai Lin Fan	<i>Land Transport Authority</i>
Members	: Dr Pritam Das	<i>National University of Singapore</i>
	Mr David Goh King Siang	<i>Singapore Manufacturing Federation</i>
	Mr Ken G Jung	<i>Singapore Electrical Contractors and Licensed Electrical Workers Association</i>
	Ms Adeline Koh	<i>Association of Consulting Engineers Singapore</i>
	Mr Benedict Koh Yong Pheng	<i>Fire Safety Managers' Association (Singapore)</i>
	Mr Lim Kian Chye	<i>Energy Market Authority</i>
	Mr Ng Eng Sin	<i>JTC Corporation</i>
	Mr Pang Tong Teck	<i>Singapore Civil Defence Force</i>
	Mr K Seshadri	<i>Individual Capacity</i>
	Mr Sim Kooi Chuan / Mr Koh Tien Beng	<i>Singapore Institute of Architects</i>
	Assoc Prof So Ping Lam	<i>Nanyang Technological University</i>
	Er. Tan Kok Koon	<i>Housing & Development Board</i>
	Mr Jack Tay / Mr Foo Ming Yann	<i>Singapore Electrical Trades Association</i>
	Dr Zhou Yi	<i>Institute of Engineers Singapore</i>

The Working Group, appointed by the Technical Committee to assist in the preparation of this standard, comprises the following experts who contribute in their *individual capacity*:

	Name
Co-Convenors	: Mr K Seshadri Mr Tan Heng Khoon
Members	: Mr Cheong Weng Yip Assoc Prof Choo Fook Hoong Er. Loh Wah Kay Er. Ong Ser Huan Mr Somesh Kumar Rakshit Maj Tan Chung Yee Mr Tay Hooi Seng Dr Ronnie Teo Mr James Wong Mr Yeo Kok Beng

The organisations in which the experts of the Working Group are involved are:

Agency for Science, Technology and Research
Enkon International Consulting Engineers Pte Ltd
Gritti Consulting Pte Ltd
Housing & Development Board
Land Transport Authority
M & P Consulting Engineers
Maxspid Enterprise Pte Ltd
Nanyang Technological University
Philips Electronics (Singapore) Pte Ltd
Singapore Civil Defence Force
TLS Design Pte Ltd
TUV SUD PSB Pte Ltd

CONTENTS

NATIONAL FOREWORD	9
FOREWORD	9
INTRODUCTION	12
1 Scope	13
1.1 General	13
1.2 Statement	14
2 Normative references	14
3 Terms and definitions	15
4 Marking	18
4.1 Mandatory marking	18
4.2 Additional marking	19
5 Dimensions	20
6 Test conditions	20
6.1 General test conditions	20
6.2 Creation of module families to reduce test effort	21
6.2.1 General	21
6.2.2 Variations within a family	21
6.2.3 Compliance testing of family members	23
7 Electrical LED module input	23
7.1 LED module power	23
7.2 Displacement factor (u.c.)	23
8 Light output	24
8.1 Luminous flux	24
8.2 Luminous intensity distribution, peak intensity and beam angle	24
8.2.1 General	24
8.2.2 Measurement	24
8.2.3 Luminous intensity distribution	24
8.2.4 Peak intensity value	24
8.2.5 Beam angle value	25
8.3 Luminous efficacy	25
9 Chromaticity coordinates, correlated colour temperature (CCT) and colour rendering	25
9.1 Chromaticity coordinates	25
9.2 Correlated colour temperature (CCT)	26
9.3 Colour rendering index (CRI)	26
10 LED module life	27
10.1 General	27
10.2 Lumen maintenance	27
10.3 Endurance tests	28
10.3.1 General	28
10.3.2 Temperature cycling test	29
10.3.3 Supply switching test	30

10.3.4	Accelerated operation life test	30
11	Verification	31
12	Information for luminaire design	31
Annex A (normative)	Method of measuring LED module characteristics	32
A.1	General	32
A.2	Electrical characteristics	33
A.2.1	Test voltage, current or power	33
A.2.2	Ageing	33
A.3	Photometric characteristics	33
A.3.1	Test voltage, current or power	33
A.3.2	Luminous flux	33
A.3.3	Luminous intensity distribution	34
A.3.4	Peak intensity	34
A.3.5	Beam angle	34
A.3.6	Colour rendering	34
A.3.7	Chromaticity coordinate values	34
Annex B (informative)	Information for luminaire design	35
B.1	Temperature stability	35
B.2	Binning procedure of white colour LEDs	35
B.3	Ingress protection	35
Annex C (informative)	Explanation of recommended LED product lifetime metrics	36
C.1	General	36
C.2	Life time specification for gradual light output degradation	37
C.3	Lifetime specification for abrupt light output degradation	38
C.4	Combined gradual and abrupt light output degradation	39
C.5	Overview of LED lifetime metrics and related lighting product groups	40
C.6	Example lifetime metric values	41
Annex D (normative)	Explanation of the photometric code	43
Annex E (normative)	Measurement of displacement factor	44
E.1	General	44
E.2	Phase shift angle definition	44
E.3	Measurements requirements	45
E.3.1	Measurement circuit and supply source	45
E.3.2	Requirements for measurement equipment	45
E.3.3	Test conditions	45
Annex F (informative)	Explanation of displacement factor	46
F.1	General	46
F.2	Recommended values for displacement factor	46
Annex G (informative)	Examples of LED dies and LED packages	48
G.1	LED die	48
G.2	LED package	49
Annex H (informative)	Test equipment for temperature measurement	50
H.1	General	50
H.2	Set-up and procedure	50
Bibliography	51

Figure 1 – Types of LED modules	13
Figure 2 – Luminous flux depreciation over test time	28
Figure C.1 – Lumen output over life of a LED-based luminaire comprised of a single LED module.....	36
Figure C.2 – Life time specification for gradual light output degradation	37
Figure C.3 – Reliability curve R_{abrupt} for abrupt light output degradation	38
Figure C.4 – Reliability curve R_{gradual} for gradual light output degradation.....	39
Figure C.5 – Combined R_{gradual} and R_{abrupt} degradation.....	40
Figure C.6 – Overview of LED lifetime metrics	41
Figure E.1 – Definition of the fundamental current phase shift angle ϕ_1 (I_1 leads U_{mains} , $\phi_1 > 0$).....	44
Figure E.2 – Definition of the fundamental current phase shift angle ϕ_1 (I_1 lags U_{mains} , $\phi_1 < 0$).....	45
Figure G.1 – Schematic drawings of LED dies	48
Figure G.2 – Schematic drawings of LED packages	49
Table 1 – Mandatory marking and location of marking ¹	19
Table 2 – LED module life time information	20
Table 3 – Optional marking and location of marking	20
Table 4 – Allowed variations within a family.....	22
Table 5 – Tolerance (categories) on rated chromaticity coordinate values	26
Table 6 – Lumen maintenance code at an operational time as stated in 6.1	27
Table 7 – Sample sizes	31
Table C.1 – Example lifetime metric values for lumen maintenance factor ratings	41
numbers in %	41
Table C.2 – Example lifetime metric values for abrupt failure.....	42
numbers in %	42
Table C.3 – Example lifetime metric values of x for median LED lamp life (combined failures).....	42
numbers in %	42
Table C.4 – Example lifetime metric values	42
Table F.1 – Recommended values for displacement factor	47

National Foreword

This Singapore Standard was prepared by a Working Group appointed by the Technical Committee on Building Facilities and Services under the direction of the Electrical and Electronic Standards Committee.

This standard is an identical adoption of International Standard IEC 62717:2014, 'LED modules for general lighting – Performance requirements' published by the International Electrotechnical Commission.

Attention is drawn to the following:

1. Where appropriate, the words 'International Standard' shall be read as 'Singapore Standard'.
2. The comma has been used throughout as a decimal marker whereas in Singapore Standards it is a practice to use a full point on the baseline as the decimal marker.

Attention is drawn to the possibility that some of the elements of this Singapore Standard may be the subject of patent rights. Enterprise Singapore shall not be held responsible for identifying any or all of such patent rights.

NOTE

1. *Singapore Standards (SSs) and Technical References (TRs) are reviewed periodically to keep abreast of technical changes, technological developments and industry practices. The changes are documented through the issue of either amendments or revisions.*
2. *An SS or TR is voluntary in nature except when it is made mandatory by a regulatory authority. It can also be cited in contracts making its application a business necessity. Users are advised to assess and determine whether the SS or TR is suitable for their intended use or purpose. If required, they should refer to the relevant professionals or experts for advice on the use of the document. Enterprise Singapore shall not be liable for any damages whether directly or indirectly suffered by anyone or any organisation as a result of the use of any SS or TR.*
3. *Compliance with a SS or TR does not exempt users from any legal obligations.*

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**LED MODULES FOR GENERAL LIGHTING –
PERFORMANCE REQUIREMENTS**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62717 has been prepared by subcommittee 34A: Lamps, of IEC technical committee 34: Lamps and related equipment.

This first edition cancels and replaces IEC PAS 62717 published in 2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC PAS 62717.

- all terms and definitions are aligned with IEC 62504 and relevant documents of CIE. For example, general terms like "rated value" are shifted to IEC 62504.
- a statement on the applicability on a population is included.
- the normative references are completed and cleaned from standards that are not in use.

- with regard to EMC, references to harmonic currents are given.
- the change, which has an effect on most parts of the standard, is the split of failure mechanisms into abrupt failures and luminous flux depreciation. Consequently, new terms and definitions, new requirements for lumen maintenance and a complete new structure and contents of Annex C are introduced.
- transition from t_{pmax} to t_{prated} is made, with the background that there is not one t_{pmax} , but a choice of $t_p(rated)$ values, in combination with lifetime.
- places where to mark (product, packaging, data sheets) are changed, and as a consequence of the split of failure mechanisms, new parameters are listed. Further, changes in the endurance test (ramping speed of temperature) are reflected in marking.
- the concept of displacement factor instead of power factor is introduced. This led to new definitions, requirements and Annexes E and F.
- the requirements on luminous efficacy are changed.
- the requirements, associated with the family concept are reviewed.
- statistics, based on confidence intervals are removed. This concerns requirements and limits for LED module power and luminous flux and deletion of Annex E.
- new requirements for lumen maintenance are introduced.
- as part of the endurance test, the maximum light decrease after accelerated operation life test is now fixed.
- with regard to the discussion on type test and sample size, the number of pieces in a test sample is drastically reduced, see Table 7.
- Annex A on measuring methods is completely restructured and reviewed, for example for ambient temperature and for shortening of stabilisation time when conducting subsequent light output measurements.
- for electrical characteristics, the ageing time may be chosen as 500 h.
- for photometric data file formats, reference is given to IEC 62722-1.
- mistakes in the photometric code (Annex D) are corrected.
- Annex G on optimised test duration is removed; instead, an INF sheet shall be published.
- from the luminaire standard, a new Annex H on "Test equipment for temperature measurement" is taken over.
- finally, the Bibliography is updated.

The text of this standard is based on the following documents:

FDIS	Report on voting
34A/1796/FDIS	34A/1817/RVD

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

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

In this standard, the following print types are used:

- requirements: roman type.

- *test specifications: italic type.*
- notes: smaller roman type.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The first edition of a performance standard (precursor: IEC PAS 62717) for LED modules for general lighting applications acknowledges the need for relevant tests for this new source of electrical light, sometimes called "solid state lighting". The publication is closely related to simultaneously developed performance standard publication (which also started with a Publicly Available Specification) for luminaires in general (IEC 62722-1) and for LED-luminaires (IEC 62722-2-1). Changes in the LED module standard will have an impact on the luminaire standards and vice versa, due to the behaviour of LED. Therefore, in the development of the present standard, a close collaboration between experts of both products has taken place.

The provisions in the standard represent the technical knowledge of experts from the fields of the semiconductor (LED chip) industry and of those of the traditional electrical light sources.

Three types of LED-modules are covered: with integral controlgear, with means of control on board, but with separate controlgear ("semi-ballasted"), and with complete separate controlgear.

LED MODULES FOR GENERAL LIGHTING – PERFORMANCE REQUIREMENTS

1 Scope

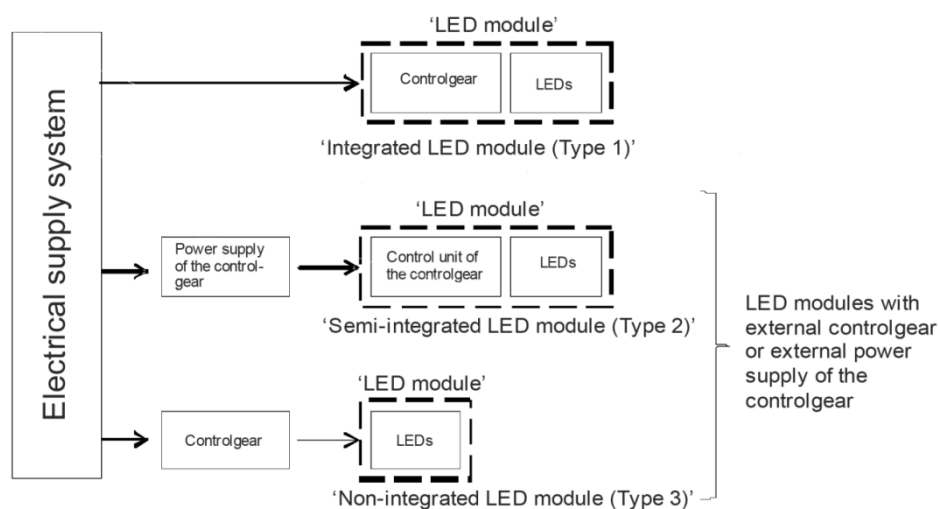
1.1 General

This International Standard specifies the performance requirements for LED modules, together with the test methods and conditions, required to show compliance with this standard. The following types of LED modules are distinguished and schematically shown in Figure 1:

Type 1: integrated LED modules for use on d.c. supplies up to 250 V or on a.c. supplies up to 1 000 V at 50 Hz or 60 Hz.

Type 2: LED modules operating with part of separate controlgear connected to the mains voltage, and having further control means inside ("semi-integrated") for operation under constant voltage, constant current or constant power.

Type 3: LED modules where the complete controlgear is separate from the module (non-integrated) for operation under constant voltage, constant current or constant power.



IEC

The power supply of the controlgear for semi-ballasted LED modules (Type 2) is an electronic device capable of controlling currents, voltage or power within design limits.

The control unit of the controlgear for semi-ballasted LED modules (Type 2) is an electronic device to control the electrical energy to the LEDs.

A LED module with separate controlgear can be either a non-ballasted LED module or a semi-ballasted LED module.

Figure 1 – Types of LED modules

The requirements of this standard relate only to type testing.

Recommendations for whole product testing or batch testing are under consideration.

This standard covers LED modules, based on inorganic LED technology that produces white light.

Life time of LED modules is in most cases much longer than the practical test times. Consequently, verification of manufacturer's life time claims cannot be made in a sufficiently confident way, because projecting test data further in time is not standardised. For that reason the acceptance or rejection of a manufacturer's life time claim, past an operational time as stated in 6.1, is out of the scope of this standard.

Instead of life time validation this standard has opted for lumen maintenance codes at a defined finite test time. Therefore, the code number does not imply a prediction of achievable life time. The categories, represented by the code, are lumen-depreciation character categories showing behaviour in agreement with manufacturer's information which is provided before the test is started.

In order to validate a life time claim, an extrapolation of test data is needed. A general method of projecting measurement data beyond limited test time is under consideration.

The pass/fail criterion of the life time test as defined in this standard is different from the life time metrics claimed by manufacturers. For explanation of recommended life time metrics, see Annex C.

NOTE When modules are operated in a luminaire, the claimed performance data can deviate from the values established via this standard due to e.g. luminaire components that impact the performance of the LED module.

The separate electronic controlgear for LED modules as mentioned in Type 2 and Type 3 is not part of the testing against the requirements of this standard.

Protection for water and dust ingress, see B.3.

1.2 Statement

It may be expected that integrated LED modules which comply with this standard will start and operate satisfactorily at voltages between 92 % and 106 % of rated supply voltage. LED modules with separate controlgear are expected to start and operate satisfactorily in combination with the specified controlgear complying with IEC 61347-2-13 and IEC 62384. All LED modules are expected to start and operate satisfactorily when operated under the conditions specified by the LED module manufacturer and in a luminaire complying with IEC 60598-1.

The requirements for individuals apply for 95 % of the population.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-845:1987, *International Electrotechnical Vocabulary – Chapter 845: Lighting*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-3-5:2001, *Environmental testing – Part 3-5: Supporting documentation and guidance – Confirmation of the performance of temperature chambers*

IEC 60081, *Double-capped fluorescent lamps – Performance specifications*

IEC 61000-3-2:2005¹, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-2:2005/AMD 1:2008

IEC 61000-3-2:2005/AMD 2:2009

IEC 61000-4-7, *Electromagnetic compatibility (EMC) – Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto*

IEC TR 61341, *Method of measurement of centre beam intensity and beam angle(s) of reflector lamps*

IEC 61347-2-13, *Lamp controlgear – Part 2-13: Particular requirements for d.c. or a.c. supplied electronic controlgear for LED modules*

IEC 62031:2008, *LED modules for general lighting – Safety specifications*

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

CIE 13.3:1995, *Method of measuring and specifying colour rendering properties of light sources*

CIE 121:1996, *The photometry and goniophotometry of luminaires*

CIE 177:2007, *Colour rendering of white LED light sources*