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INTERNATIONAL STANDARD

Fibre optic active components and devices – Reliability standards – Part 3: Laser modules used for telecommunication

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FIBRE OPTIC ACTIVE COMPONENTS AND DEVICES – RELIABILITY STANDARDS –

Part 3: Laser modules used for telecommunication

FOREWORD

International Standard IEC 62572-3 has been prepared by subcommittee 86C: Fibre optic systems and active devices of IEC technical committee 86: Fibre optics.

This third edition cancels and replaces the second edition published in 2014. This third edition constitutes a technical revision in which errors in Table 1 and Table 2 have been corrected.

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

CDV	Report on voting
86C/1302/CDV	86C/1345/RVC

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.

A list of all parts in the IEC 62572 series, published under the general title *Fibre optic active components and devices – Reliability standards*, can be found on the IEC website.

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

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- withdrawn,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

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

INTRODUCTION

The laser modules covered by this International Standard are purchased by system suppliers (SS) to be inserted in equipment, which in turn are supplied/sold to a system operator (SO) or a network operator (see definitions in Clause 3).

For the system operator to act as an informed buyer, he/she should have knowledge of the potential risks posed by the use of critical components.

Optoelectronic component technology is continuing to develop. Consequently, during product development phases, many failure mechanisms in laser modules have been identified. These failure mechanisms, if undetected, could result in very short laser lifetime in system use.

FIBRE OPTIC ACTIVE COMPONENTS AND DEVICES – RELIABILITY STANDARDS –

Part 3: Laser modules used for telecommunication

1 Scope

This part of IEC 62572 deals with reliability assessment of laser modules used for telecommunication.

The aim of this standard is

– to establish a standard method of assessing the reliability of laser modules in order to minimize risks and to promote product development and reliability;

– to establish means by which the distribution of failures with time can be determined. This should enable the determination of equipment failure rates for specified end of life criteria.

In addition, guidance is given in IEC TR 62572-2.

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 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

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

IEC 60749-6, *Semiconductor devices – Mechanical and climatic test methods – Part 6: Storage at high temperature*

IEC 60749-8, *Semiconductor devices – Mechanical and climatic test methods – Part 8: Sealing*

IEC 60749-10, *Semiconductor devices – Mechanical and climatic test methods – Part 10: Mechanical shock*

IEC 60749-11, *Semiconductor devices – Mechanical and climatic test methods – Part 11: Rapid change of temperature – Two-fluid-bath method*

IEC 60749-12, *Semiconductor devices – Mechanical and climatic test methods – Part 12: Vibration, variable frequency*

IEC 60749-25, *Semiconductor devices – Mechanical and climatic test methods – Part 25: Temperature cycling*

IEC 60749-26, *Semiconductor devices – Mechanical and climatic test methods – Part 26: Electrostatic discharge (ESD) sensitivity testing – Human body model (HBM)*

IEC TR 62572-2, *Fibre optic active components and devices – Reliability standards – Part 2: Laser module degradation*

MIL-STD-883, *Test method standard – Microcircuits*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this document the following definitions apply.

3.1.1
laser module
packaged assembly containing a laser diode with/without photodiode

Note 1 to entry: The module may also include a cooler and temperature sensor to enable laser temperature to be controlled and monitored. The optical output is normally via an optical fibre pigtail.

3.1.2
submount
substrate upon which a laser diode or photodiode may be mounted for assembly into the laser module

Note 1 to entry: Components on submounts are also subject to qualification testing.

3.1.3
laser module manufacturer
LMM
manufacturer of laser modules who provides devices meeting the requirements of the relevant detail specification (DS) and the customer's reliability requirements

3.1.4
network operator
NO
organization which operates a telecommunications network

3.1.5
system supplier
SS
manufacturer of telecommunications/data transmission equipment containing optoelectronic semiconductor lasers

Note 1 to entry: The system supplier can be a laser module customer.

3.1.6
system operator
SO
network operator of telecommunications/data transmission equipment containing opto-electronic semiconductor lasers in the transmission path

Note 1 to entry: The system may also be part of other more extensive systems, for example telecommunications, rail, road vehicles, aerospace or weapons.

3.1.7
capability qualifying components
CQC
components selected to represent critical stages of the process and limiting or boundary characteristics of mechanical and electro-optic design

Note 1 to entry: Such components should aid the identification of end product failure mechanisms to enable the determination of activation energies.

3.2 Symbols and abbreviations

T_A	minimum storage temperature
T_B	maximum storage temperature
T_c	module case temperature
T_s	submount temperature
$T_{s\ nom}$	recommended submount temperature
$T_{op\ min}$	module minimum operating temperature
$T_{op\ max}$	module maximum operating temperature
$T_{stg\ min}$	module minimum storage temperature
$T_{stg\ max}$	module maximum storage temperature
Qc	test for gross leak detection
Qk	test for fine leak detection
p	periodicity (in months)
n	sample size
CA	capability approval
CQC	capability qualifying components
DS	detail specification
LMM	laser module manufacturer
ML	median life
NO	network operator
QA	quality approval
QIP	quality improvement programmes
RGA	residual gas analysis
SO	system operator
SS	system supplier

4 Laser reliability and quality assurance procedure

4.1 Demonstration of product quality

This standard (where required by the specification) gives the minimum mandatory requirements and is part of a total laser reliability and quality assurance procedure adopted by the laser module manufacturer.

It also provides guidance on the activities of system suppliers and system operators and provides feedback on field performance to laser module manufacturers and system suppliers.

The laser module manufacturer shall be capable of demonstrating, by means of qualification approval of devices, technology approval or capability approval of the manufacturing process, the following:

a) a documented and audited manufacturing process including the qualification of purchased components in accordance with an internationally recognized quality management system;
b) a performance qualification programme, including for example, accelerated life testing, burn-in and screening of components and modules;
c) a qualification maintenance programme to ensure continuity of reliability performance;

d) a procedure to provide feedback on reliability issues to development and production.

4.2 Testing responsibilities

4.2.1 General

The testing detailed in Table 1 and Table 2 is to be performed by the laser module manufacturer and component suppliers (where applicable). Additional testing may be specified in the specification.

4.2.2 Recommendation applicable to laser customer/system supplier

The system supplier is recommended to have a programme to analyse and verify the results including failure analysis. This programme includes an independent life test of fully packaged laser modules (see Table 2, test 1 and/or test 2 and 3 and/or test 5 (sample size >10 per test)).

4.2.3 Recommendation applicable to system operator

The system operator is recommended to have a programme to monitor and report field failure rates in sufficient detail to enable the system supplier and laser module manufacturer to initiate any necessary corrective actions at an early stage in the lifetime of a product.

Suppliers may have different approaches (i.e. to reliability concepts) during the development of product maturity, and resource limitations may dictate testing strategies.

Alternative tests and activities to those specified are permitted, provided the LMM/SS/SO can show intent to remove end-product failures and the associated failure mechanisms. However, this will require significant data to substantiate compliance.

4.3 Quality improvement programmes (QIPs)

Quality improvement programmes (QIPs) shall be initiated with component suppliers and customers (SOs, SSs and LMMs) to address non-compliances (including quality and reliability problems identified during subsequent service life of the laser). The correction of non-compliances and subsequent QIPs are a required strategy to minimize reliability risks. The operation of QIPs should be stated in the quality approval (QA) generic and capability approval documents.

5 Tests

5.1 General

The tests described in Table 1 and Table 2 are designed to accelerate the main failure mechanisms known to be reliability hazards in laser modules and shall follow the guidance from IEC TR 62572-2. Where appropriate, the CQC shall demonstrate an ability to reduce end product failure mechanisms. Final product validation is required to demonstrate that CQCs are operating at the boundaries of the process or technology. These tests will reduce the risk of unreliable components entering system use and will enable estimates to be made of the distribution of laser lifetimes and hence the laser failure rates.

The sample size and level of testing may vary depending on the business volume between the laser customer/system supplier (SS) and laser module manufacturer (LMM). This information will be given in the capability approval (CA) document and the specification where appropriate.

It is essential that the lasers evaluated are entirely representative of standard production devices and have passed all the production and/or specified (where applicable in the specification) burn-in and screening procedures.

Table 1 – Initial qualification

These tests will normally be performed by the laser manufacturer as part of an initial qualification programme.

Table 2 – Maintenance of qualification

These tests cover periodic monitoring performed on production devices to ensure that the quality and reliability performance established during initial qualification is maintained or improved.

5.2 Structural similarity

Where a range of laser modules is produced by a laser manufacturer, there may be some significant structural similarity between different type codes. A combination of results from different test programmes, where appropriate, is therefore permitted.

Consideration should be given to the fact that minor differences in technology or processing can have a major impact on reliability, whilst not being apparent during quality assessment.

Evidence shall be presented which demonstrates that all results are directly relevant.

5.3 Burn-in and screening (when applicable in the specification)

NOTE See IEC TR 62572-2.

The screening test should be designed by the laser module manufacturer specifically for his particular technology. Any approach based on similarity to that which is performed by other manufacturers is good for comparison purposes, but can be ineffective in achieving the actual screening goal. This is particularly true for fibre optic components whose technology is not yet mature and varies significantly from supplier to supplier.

Where a manufacturer can demonstrate component and process stability, screening procedures may be revised.

Table 1 – Initial qualification (*1 of 3*)

Test no.	Test	References	Conditions	n
1	Initial endurance test			
1.1	a) Module with thermoelectric cooler		Φ_e specified, constant power Temperature: $T_c = T_{op\ max}$ $T_s = T_{s\ nom}$ Duration: 5 000 h [a]	25
1.2	b) Module without thermoelectric cooler		Φ_e specified, constant power Temperature: $T_c = T_{op\ max}$ Duration: 5 000 h [a]	25
1.3	Laser diode (submount)		Temperature: at least two test temperatures: Φ_e specified, constant power $T_{s1} = T_s$ max $T_{s2} \leq (T_{s1} -20)$ °C or $T_{s2} \leq (T_{s1} -10)$ °C if applicable Duration: > 5 000 h	See footnote [d] See footnote [d]

Table 1 *(2 of 3)*

Test no.	Test	References	Conditions	*n*
1.4	Photodiode (in representative package)		Temperature: at least two test temperatures: V_r or I_r specified T_{s1} = 125 °C min [b] $T_{s2} \leq (T_{s1} - 30\ °C)$ Duration: > 1 000 h	See footnote [d] See footnote [d]
1.5	High temperature storage of the thermoelectric cooler		$T = T_{stg\ max}$ of the cooler Duration: 1 000 h	25
1.6	Power cycle tests cooled devices		Number of cycles: 20 K $T_c = T_{op\ max}$ $T_s = T_c$ to $(T_c - \Delta T_{max})$	25
1.7	High-temperature storage of the thermal sensor		$T = T_{stg\ max}$ of the sensor	25
2	Fibre test			
2.1	Fibre proof test		Proof test [d] Duration [d] Min. bend radius [d]	10
2.2	Fibre retention			
2.2.1	Fibre pull		Fibre pull [d]	10
2.2.2	Side pull		Side pull [d]	
3	Change of temperature		See footnotes [c] and [d]	
3.1	Rapid change of temperature	IEC 60749-11	Temperature: $T_A = T_{stg\ min}$ $T_B = T_{stg\ max}$ Number of cycles = 50	10
3.2	Temperature cycling	IEC 60749-25 IEC 60068-2-14	Temperature: $T_A = T_{stg\ min}$ $T_B = T_{stg\ max}$ > 1 °C/min Number of cycles = 500	10
4	Sealing	IEC 60749-8	See footnote [d] Test Qk followed by Test Qc See footnotes [c] and [d] and Clause A.6	10
5	Shock and vibration		See Clause A.7	
5.1	Shock	IEC 60749-10	5 000 m/s^2, 0,5 ms with/without thermoelectric cooler, 15 000 m/s^2, 0,5 ms without thermoelectric cooler (where appropriate) 6-directions, 5 times each	10
5.2	Vibration	IEC 60749-12	20 Hz to 2 000 Hz, 200 m/s^2, 3-directions, 30 min each	10

Table 1 *(3 of 3)*

Test no.	Test	References	Conditions	n
6	High temperature storage (not applicable if module life test performed at equivalent case temperature and submount temperature)	IEC 60749-6	Temperature: $T = T_{stg\ max}$ Duration: > 2 000 h (See IEC TR 62572-2)	10
7	ESDS, modules a) Lasers b) Photodiodes	IEC 60749-26	Human body model, see Clause A.9 5 discharges/test voltage, charge-discharge cycle > 0,1 s	5 per wafer
8	Residual gas analysis	MIL-STD-883, Method 1018	See footnote [d] See Clause A.10	6
9	Low-temperature storage	IEC 60068-2-1	$T = T_{stg\ min}$ Duration: > 1 000 h	10

[a] Provided data about the distribution of wear-out lifetime is accumulated with sufficient accuracy. Provisional approval for product shipment shall be granted at 2 000 h. It is also recommended to continue the test until accurate extrapolation of lifetime is possible with an upper limit of 10 000 h. Durations up to 5 000 h may be needed for accurate lifetime prediction.

[b] Or as limited by technology.

[c] Results from tests 1.1 and 1.2 shall be supplemented by a laser customer/SS independent test of fully packaged modules in accordance with Table 2, test 2 and/or test 3 (sample size ≥ 10 per test). See also 4.2.

[d] Number of samples and conditions shall be determined by a laser customer/SS and LMM.

Table 2 – Maintenance of qualification *(1 of 2)*

Test no.	Test	References	Conditions	*n*	*p*
1	Ongoing reliability test a) Module (cooled) b) Module (uncooled) c) Laser diode (submount) d) Photodiode		Periodic testing: Test 1.1 Test 1.2 Test 1.3 Test 1.4	See NOTES 10 10 25 [a] 25 [a]	6
2	Temperature cycling	IEC 60749-25 IEC 60068-2-14	Temperature: $T_A = T_{stg\ min}$ $T_B = T_{stg\ max}$ > 1 °C /min Periodic testing: number of cycles = 100 (see NOTE 1)	10	6
3	Sealing	IEC 60749-8	See NOTE 2 Test Qk followed by Test Qc See NOTES and Clause A.6	10	6
4	Shock and vibration		See NOTES and Clause A.7		
4.1	Shock	IEC 60749-10	5 000 m/s^2, 0,5 ms with/without thermoelectric cooler, 15 000 m/s^2, 0,5 ms without thermoelectric cooler (where appropriate), 6-direction, 5 times each	10	12
4.2	Vibration	IEC 60749-12	20 Hz to 2 000 Hz, 200 m/s^2 3-direction, 30 min each	10	12
5	High temperature storage (not applicable if module life test performed at equivalent case temperature and submount temperature)	IEC 60749-6	Temperature: $T = T_{stg\ max}$ Duration: > 2 000 h Periodic testing: see NOTES (See IEC TR 62572-2)	10	12
6	ESDS, modules a) Lasers b) Photodiodes	IEC 60749-26	Periodic testing: see Clause A.9 Human body model 5 discharges/test voltage, Charge-discharge cycle > 0,1 s	5 per wafer	12
7	Residual gas analysis	MIL-STD-883, Method 1018	See NOTE 2 Periodic testing: see NOTES and Clause A.10	See NOTE 2	6

NOTE 1 Results of test 2 are supplemented by a laser customer/system supplier (SS) independent test of fully packaged modules in accordance with Table 2, test 2 and/or test 3 and/or test 5 (sample size ≥ 10 per test). See also 4.2.

NOTE 2 Number of samples and conditions are determined by a laser customer/SS and LMM.

[a] Out of different wafers.

6 Activities

6.1 Analysis of reliability results

The laser module customer/system supplier (SS) shall have a programme to analyse and verify a laser manufacturer's reliability claims. In particular

- life test data for the complete laser module,
- life test data for initial components, for example laser diode and photodiode,
- environmental test result, i.e. inspection requirements group B, C of the detail specification;
- where appropriate, the data and test results of appropriate CQCs (see Clause 5).

The analysis of results should lead to reporting of the laser module reliability parameters for each of the laser module types. Minimum reliability parameters are presented in Table 3.

Where data reveals more than one wear-out mechanism, median life and dispersion in each case shall be stated.

The failure criteria used to derive these reliability parameters shall be agreed between the laser customer/system supplier (SS) and laser module manufacturer (LMM). The criteria will be stated in the detail specification (see IEC TR 62572-2).

Table 3 – Performance for laser module reliability parameters

Parameter	Measured value
Median life (ML) at 25 °C or 55 °C[a]	Years
Dispersion(s)	
Wear-out failure rate at 5 years (λ)5 at 10 years (λ)10 at 20 years (λ)20	 FITs FITs FITs
Wear-out activation energy	eV
Random failure rate (λa) at 25 °C[b] Confidence limits used	 FITs %
Random failure activation energy	eV

Guidance on these activities is given in IEC TR 62572-2.

NOTE This table assumes a log-normal distribution of times to failure. The dispersion parameter is the standard deviation of the logarithm to the base 'e' of the times to failure (see IEC TR 625722-2).

[a] Special attention should be paid to all extrapolation models used, and the justification for activation energies employed in reliability predictions is to be stated.

[b] The reference temperature used for all parameters in this table is 25 °C. An alternative reference temperature (50 °C) may be used provided activation energies are given.

6.2 Technical visits to LMMs

Laser module designs continue to evolve, and an LMM may introduce significant changes which impinge on reliability. Under the negotiation between customer and manufacturer, technical visits should be performed until there is sufficient evidence of a maturing technology and production stability. These technical meetings/visits shall contain an item on the agenda that concerns quality and reliability. Where an LMM holds a capability approval, the frequency of these technical visits may be reduced provided the manufacturer can demonstrate

a) that the CQCs fully represent any relevant design, process updates and reliability issues,

b) satisfactory self-audit of the quality system.

6.3 Design/process changes

The customer/system supplier (SS) shall be informed by the laser module manufacturer (LMM) of any design or process change which may affect the form, fit or function of the end product.

6.4 Deliveries

Laser module designs will continue to evolve and therefore each delivered lot shall be manufactured according to a stated technology and production process.

This should be verified by the supplier and customer before delivery.

6.5 Supplier documentation

The laser customer/system supplier (SS) and component manufacturer or LMM shall incorporate, wherever possible, the tests and activities described in this standard into their in-house component qualification, or where appropriate, capability approval procedures and purchasing specifications. This documentation will be used in reliability/technical presentations, tender submissions and marketing briefs to customers.

Annex A
(informative)

Guidance on testing in Table 1 and Table 2

A.1 Laser module life tests containing thermoelectric coolers (Table 1, test 1.1)

With laser modules containing thermoelectric coolers (for example Peltier), it is difficult to provide a significant degree of overstress to all key components simultaneously. During “normal operation”, the laser submount temperature is usually controlled at T_s = 25 °C. However, for a life test with a case temperature of $T_c = T_{op\ max}$, a useful stress can be obtained for the laser diode, fibre fixing, photodiode and thermal sensor if the cooler is operated at a relatively high current to maintain a submount temperature of $T_s = T_{s\ nom}$. The conditions in Table A.1 are recommended.

Some additional testing of the cooler is recommended, for example $T_c = T_{op\ max}$ and $T_s = T_s$ - 10 °C.

Table A.1 – Recommended life test conditions for laser modules containing Peltier coolers

Case temperature	$T_{op\ max}$
Laser submount temperature	$T_s = T_{s\ nom}$
Optical power	Fibre output set to P_{max} at start of life test (using monitor circuit)
Laser current	To maintain constant monitor output
Monitor current	Normal bias
Thermal sensor current	Normal bias
Cooler current	To maintain constant thermistor resistance (or sensor conditions)
Duration	> 5 000 h

A.2 Laser module life tests for uncooled modules (Table 1, test 1.2)

For modules without thermoelectric coolers (for example Peltier), life tests can be readily performed over a range of temperatures up to the recommended maximum operating temperature for the module. During initial qualification, service life tests at two or more temperatures, for example $T_c = T_{op\ max}$ and T_c in the range of 40 °C to 50 °C, are recommended. Here, the accuracy of lifetime estimation becomes high in proportion to the number of test levels.

An additional life test at low temperature (duration > 2 000 h at $T_{op\ min}$) may be required for modules containing epoxies or organic materials.

If only a single life test is to be performed, for example during maintenance of qualification testing, the conditions in Table A.2 are recommended.

Table A.2 – Recommended life test conditions for uncooled laser modules

Case temperature	$T_{op\ max}$
Optical power	Fibre output set to P_{max} at start of life test (using monitor circuit)
Laser current	To maintain constant monitor photocurrent
Monitor photocurrent	Normal bias
Duration	> 5 000 h

A.3 Laser diode life tests on submounts (Table 1, test 1.3)

The laser life test shall be performed with the laser operating at constant light output, as it would be in normal operation, unless otherwise agreed with the user. Temperatures in the range T_s = 50 °C to 80 °C are often used. The acceleration in the rate of degradation, relative to normal operation, is therefore relatively small. The maximum temperature at which life tests can be performed under lasing operating conditions is usually in the range T_s = 70 °C to 100 °C. However, constant current/life tests at temperatures up to T_s = 150 °C can be useful in studying the reliability of contact metallizations. Actual failures do not often occur in well screened laser diodes tested at temperatures T_s < 90 °C. In order to estimate the laser life, some extrapolation is required to predict when the threshold or operating current will exceed the pre-determined failure criterion. To obtain a reasonable increase in operating current, a life test duration greater than 5 000 h is required.

If a single life test is to be performed, for example during maintenance of qualification testing, the conditions in Table A.3 are recommended.

Table A.3 – Recommended laser diode life test conditions

Temperature	T_s = 70 °C
Optical power	Maximum specified
Bias	To maintain constant monitor output
Duration	> 5 000 h

A.4 Monitor photodiode life tests (Table 1, test 1.4)

Photodiode life tests are best performed with the devices under reverse bias if the susceptibility to increased dark current is to be assessed. To obtain failures in a reasonable timescale, temperatures in the range T_s = 125 °C to 200 °C are usually required. Devices with organic passivations should be tested at temperatures below the curing temperature of the passivation.

Increased bias voltage can also be used to accelerate failure, but the dependence of lifetime on voltage would then need to be determined before a prediction of operating lifetime could be made.

It is necessary for measurements of photodiode dark currents to include measurement at the normal operating temperature. Measurements made at only the life test temperature may not detect increased surface leakage, because bulk dark currents dominate at high temperatures.

Failed photodiodes with increased dark currents (as a result of the accumulation of mobile charge) will often recover quickly if stored at high temperatures without bias. It is essential, that at the end of the test duration, the reverse bias conditions are maintained until the temperature is below 30 °C. The post test measurements shall be completed within 3 h. The increase in dark current of photodiodes with exposed junctions (for example unpassivated mesa devices) is very sensitive to the package atmosphere, and small traces of oxygen or water vapour can result in decreased lifetimes. Life tests should therefore be performed with the photodiodes sealed in representative hermetic packages, and not on open submounts. Tests in flowing (nominally dry) nitrogen can produce variable results. The conditions in Table A.4 are recommended.

Table A.4 – Recommended photodiode life test conditions

Temperature	In the range T_s = 125 °C to 200 °C
Bias	Specified maximum reverse bias voltage. Bias to be maintained during cool down prior to measurements
Duration	1 000 h
Atmosphere	Photodiode in representative hermetic package

A.5 Temperature cycling and thermal shock (Table 1, test 3 and Table 2, test 2)

It is difficult to quantify the acceleration (with respect to normal operation) obtained from a temperature cycling test. Nevertheless, it has been clearly demonstrated that temperature cycling from T_c = –40 °C to +70 °C can reveal potentially serious hazards in laser modules associated with fibre instability, thermal mismatch between piece parts (for example coolers and submounts), and with fibre breaks.

For initial qualification, number of cycles = 500 from $T_{stg\ min}$ to $T_{stg\ max}$ are required. For periodic testing (3 and/or 6 monthly), the number of cycles = 100. The temperature cycling procedure should follow either:

a) IEC 60068-2-14, Test Na: two-chamber method;
b) IEC 60068-2-14, Test Nb: single-chamber method, rate of change equal to 1 °C/min, 3 °C/min, or 5 °C/min.

Well designed and constructed modules should be able to withstand such a test with negligible changes in module performance.

A.6 Sealing/hermeticity (Table 1, test 4 and Table 2, test 3)

The post-test assessment for test 4, Table 1 and test 3, Table 2 shall be fine-leak testing, Test Qk, followed by the gross-leak Test Qc. Suitable precautions shall be taken to eliminate absorption of helium by the fibre coating to avoid measurement errors.

A.7 Shock and vibration (Table 1 , test 5 and Table 2, test 4)

These tests are designed to simulate conditions involving vibration and shock that a component may be subjected to in service or during transportation. For a module with thermoelectric cooler, the cooler is the limiting device, so the shock test should be limited to 5 000 m/s^2.

A.8 High-temperature storage (Table 1, test 6 and Table 2, test 5)

Temperature storage testing has the advantage of being relatively inexpensive because no bias circuitry is required. Provided the test is performed at or below the maximum storage temperature for the module $T_c \leq T_{stg\ max}$, it can be regarded as non-destructive. Storage at high temperatures (for example T_c = 70 °C, duration = 1 000 h) will, although the stress is relatively small, provide useful protection against major problems with fibre alignment instability and will identify some potential metallization and solder failure mechanisms, for example thermoelectric cooler or thermistor failures.

A.9 Electrostatic discharge sensitivity (ESD) (Table 1, test 7and Table 2, test 6)

Optoelectronic components are sensitive to damage by electrostatic discharge (ESD) at all stages during manufacture, testing, assembly into equipment and operation. Exposure to ESD can result in sudden failure, parametric shifts, or even latent damage leading to a reduced lifetime during subsequent operation. The sensitivity of the laser and monitor photodiode to ESD damage should be determined so that the appropriate level of precautions can be taken to avoid damage.

The minimum recommended testing for modules is to subject five laser diodes and five monitor photodiodes on a wafer basis, to the “human body model” test described in IEC 60749-26. However, rather than applying a single go-no-go test condition, transients of increasing voltage should be applied to determine the threshold at which failures occur.

Failure should be defined as a parametric change in

– photodiode dark current or in laser threshold current;
– slope efficiency;
– forward voltage;
– reverse leakage current or light output spectrum.

The criteria are given in IEC TR 62572-2.

A.10 Residual gas analysis (RGA) (Table 1, test 8 and, Table 2, test 7)

Certain laser module reliability hazards associated with high package water content are unlikely to be detected with the testing described in Table 1 and Table 2. Hermeticity testing and residual gas analysis of transmitter modules is necessary to demonstrate that the module package contains a dry, inert atmosphere throughout its operating life. High-temperature life testing alone is not likely to detect reliability hazards associated with high package water content. See also Clause A.2, Table 1, Test 8 and Table 2, test 7.

Caution: the pre-bake temperature for RGA in MIL-STD-883, method 1018 is 100 °C. This may be greater than the storage temperature $T_{stg\ max}$ of most optoelectronic components. A lower pre-bake temperature of $T_c = T_{stg\ max}$ for a longer period is therefore recommended until the background level of RGA remains constant. This level can then be eliminated from the results.

Bibliography

IEC 60747-1, *Semiconductor devices – Part 1: General*

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