BS EN 62343-2:2014

BSI Standards Publication

Dynamic modules

Part 2: Reliability qualification

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National foreword

This British Standard is the UK implementation of EN 62343-2:2014. It is identical to IEC 62343-2:2014. It supersedes BS EN 62343-2:2011 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/86, Fibre optics, to Subcommittee GEL/86/3, Fibre optic systems and active devices.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2014

ISBN 978 0 580 82510 1

ICS 33.180.10

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 October 2014.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 62343-2

September 2014

ICS 33.180

Supersedes EN 62343-2:2011

English Version

Dynamic modules - Part 2: Reliability qualification (IEC 62343-2:2014)

Modules dynamiques - Partie 2: Qualification de fiabilité (CEI 62343-2:2014)

Dynamische Module - Teil 2: Beurteilung der Zuverlässigkeit (IEC 62343-2:2014)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 62343-2:2014 E

Foreword

The text of document 86C/1185/CDV, future edition 2 of IEC 62343-2, prepared by SC 86C "Fibre optic systems and active devices" of IEC/TC 86 "Fibre optics" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62343-2:2014.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-06-01
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2017-09-01

This document supersedes EN 62343-2:2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 62343-2:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61000-4-2	NOTE	Harmonized as EN 61000-4-2.
IEC 61000-4-3	NOTE	Harmonized as EN 61000-4-3.
IEC 61000-4-4	NOTE	Harmonized as EN 61000-4-4.
IEC 61000-4-5	NOTE	Harmonized as EN 61000-4-5.
IEC 61000-4-6	NOTE	Harmonized as EN 61000-4-6.
IEC 61291-5-2	NOTE	Harmonized as EN 61291-5-2.
IEC 61300-2-5	NOTE	Harmonized as EN 61300-2-5.
IEC 61300-2-9	NOTE	Harmonized as EN 61300-2-9.
IEC 61300-2-42	NOTE	Harmonized as EN 61300-2-42.
IEC 61300-2-44	NOTE	Harmonized as EN 61300-2-44.
IEC 61753-1	NOTE	Harmonized as EN 61753-1.
CISPR 22	NOTE	Harmonized as EN 55022.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

Publication	Year	Title	EN/HD	Year
IEC 61300-2-1	-	Fibre optic interconnecting devices and passive components - Basic test and measurement procedures -- Part 2-1: Tests - Vibration (sinusoidal)	EN 61300-2-1	-
IEC 61300-2-4	-	Fibre optic interconnecting devices and passive components - Basic test and measurement procedures -- Part 2-4: Tests - Fibre/cable retention	EN 61300-2-4	-
IEC 61300-2-12	-	Fibre optic interconnecting devices and passive components - Basic test and measurement procedures -- Part 2-12: Tests - Impact	EN 61300-2-12	-
IEC 62005-9-1	-	Fibre optic interconnecting devices and passive components - Reliability -- Part 9-1: Qualification of passive optical components	EN 62005-9-1[1)]	-
IEC 62005-9-2	-	Reliability of fibre optic interconnecting devices and passive optical components -- Part 9-2: Reliability qualification for single fibre optic connector sets - single mode	-	-
IEC 62572 series		Fibre optic active components and devices - Reliability standards	EN 62572 series	
ISO 9000	-	Quality management systems - Fundamentals and vocabulary	-	-

[1)] At draft stage.

CONTENTS

DYNAMIC MODULES –

Part 2: Reliability qualification

1 Scope

This part of IEC 62343 applies to dynamic modules and devices (DMs) which are commercially available. Examples are tuneable chromatic dispersion compensators, wavelength selective switches and optical channel monitors.

Optical amplifiers are not included in this list, but are treated in IEC 61291-5-2.

For reliability qualification purposes, some information about the internal components, parts and interconnections is needed; these internal parts are treated as black boxes. This standard gives requirements for the evaluation of DM reliability by combining the reliability of such internal black boxes.

The objectives of this standard are the following:

- to specify the requirements for the reliability qualification of DMs;
- to give the minimum list of reliability qualification tests, requirements on failure criteria during testing and on reliability predictions, and give the relevant normative references.

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 61300-2-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-1: Tests – Vibration (sinusoidal)*

IEC 61300-2-4, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-4: Tests – Fibre/cable retention*

IEC 61300-2-12, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-12: Tests – Impact*

IEC 62005-9-1, *Fibre optic interconnecting devices and passive components – Reliability – Part 9-1: Qualification of passive optical components*[1]

IEC 62005-9-2, *Reliability of fibre optic interconnecting devices and passive optical components – Part 9-2: Reliability qualification for single fibre optic connector sets – Single mode*

IEC 62572 (all parts), *Fibre optic active components and devices – Reliability standards*

ISO 9000: *Quality management systems – Fundamentals and vocabulary*

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[1] To be published.

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
failure
non-compliance to product specification or change in parameters as set by the standard or agreed by the customer and supplier

3.1.2
qualification
commonly used as the abbreviation for reliability qualification

Note 1 to entry: It is used as a formal testing to determine whether or not the product is suitable for telecom applications and, therefore, “pass or fail” is the expected outcome

Note 2 to entry: This is different from a reliability test, which is in nature a reliability “engineering test”. Reliability tests are designed to understand the reliability consideration or estimate the reliability of the product. Pass or fail is not the main output.

3.1.3
reliability
< time period > minimum period of DM continuous operation without failure at specified operating and environmental conditions

3.1.4
<reliability
<probability> probability to perform required functions at specified operating and environmental conditions

Note 1 to entry: The reliability of a DM is expressed by either of the following two parameters: mean time between failure (MTBF) and failures in time (FIT):

- the MTBF is the mean period of DM continuous operation without any failure at specified operating and environmental conditions;
- the FIT is the number of failures expected in 10^9 device-hours at specified operating and environmental conditions.

3.2 Abbreviated terms

DM	dynamic module
DS	detail specification
ESD	electrostatic discharge
FIT	failure in time
FMEA	failure mode and effects analysis
LCD	liquid crystal device
MTBF	mean time between failure
RH	relative humidity
UCL	upper confidence level
VOA	variable optical attenuators

4 Reliability qualification considerations

4.1 General

Since DMs are relatively new products in the commercial market and involve different technologies, the requirements included in this standard will need to be reviewed as technology progresses.

4.2 General consideration approach

It is worth emphasizing the fundamental approach of reliability qualification adopted in this standard:

a) Any parts that can be effectively qualified on their individual levels shall be qualified at that level. Their qualification shall be based on IEC standards or other industrial standards in the absence of such IEC standards.

b) The qualification tests required at DM level shall be based on the degradation mechanisms and failure modes that cannot be effectively detected in the lower part levels. At the DM level, the qualification tests shall not attempt to discover or identify those degradation mechanisms and failure modes that can be discovered in the lower assembly levels than the final product level. For example, if all parts in the DM can be effectively tested for damp heat-accelerated degradations, there is no need to repeat the damp heat test at the DM level.

4.3 DM product design

A DM is an assembly of various components, parts and interconnections. There are two basic designs in the current commercial DM market:

a) Design 1: parts (as a general term that includes components, parts and interconnections used to build a DM from the of point of view of this standard) are packaged separately. Their packages are usually either hermetic or moisture-resistant. They are integrated into a housing (usually non-hermetic or not moisture-resistant).

b) Design 2: some parts used in DMs are unpackaged basic optical elements (e.g. crystals, lenses, mirrors, etc.). These parts cannot be effectively qualified by themselves. These parts/elements are integrated and packaged inside a hermetic box or moisture-resistant box.

In Design 1, the individual parts can be tested and qualified individually and therefore, the DM qualification does not have to repeat the tests that are performed in the part levels for the same degradation mechanisms and failure modes.

In Design 2, the DM qualification is again focused on the tests that cannot be effectively performed in the lower assembly levels (i.e., the basic part level). However, in this case there are usually more tests required since the parts cannot be effectively tested at the part level individually.

Due to the differences in the designs, and therefore different mechanisms and failure modes, different qualification test approaches have to be developed separately. They are described in 5.4.4 for Design 1 and 5.4.5 for Design 2, respectively.

5 Reliability qualification requirements

5.1 General

For the purpose of this standard, each internal component, part and interconnection shall be treated as a black box. It is also important to point out that the parts in the DM of this design include the fibre splicing, fibre routing and fibre anchoring, as well as how the fibre exits from the housing and how parts are mounted.

This standard is based on the assumption that the reliability of a DM can be evaluated with sufficient confidence from the FIT rates of its internal black boxes when the assembly process of the constituents has been qualified.

There are degradation and failures not due to part failures. An example is the fibre routing and fibre holders. The quality and reliability of the assembling, for example fibre routing, shall be assessed and qualified through the process evaluation and qualification. The procedures to qualify the assembly process are described in 5.4.3.

The internal black boxes often constituting a DM are listed below:

- passive optical components, including patch cords, pigtails, connectors and splices;
- active optical components;
- electronics, including PCBs, electrical connectors, etc.
- others (e.g. fibre splicing, fibre routing and fibre anchoring, as well as how the fibre exits from the housing and how components are mounted).

The DM manufacturers shall declare the number and type of the internal black boxes constituting the DM and give the failure rates (in FITs) for each black box.

The DM failure rate shall be calculated by suitably combining the failure rates in FITs of its black boxes, as described in the 5.5.2. The model and assumptions used in DM failure rate calculation shall be provided and justified for review, if the DM manufacturer has so requested.

5.2 Demonstration of product quality

Since the reliability qualification tests are performed on a limited number of units, it is essential to have a quality management system in place to assure that the quality of all units is consistent. Testing on a limited number of samples will be representative of the production units to be delivered after the qualification is completed.

This standard (where required by the detailed specification) specifies the minimum mandatory requirements to assess reliability qualification of a DM and is intended to be part of a total DM reliability program and quality management system developed and implemented by the DM manufacturer.

The DM manufacturer shall demonstrate:

- a documented and audited manufacturing process, including the reliability qualification of purchased parts, in accordance with ISO 9000;
- performance data of production units shall be available for review, and its distribution shall show processes are under adequate controls;
- a reliability qualification programme, including, for example, accelerated life testing, burn-in and screening of parts and DMs;
- a reliability qualification maintenance programme to ensure continuity of qualification status (this can be achieved by means of periodic reliability qualification tests of the product or similar products);
- a procedure to ensure an appropriate feedback to development and production on reliability issues.

5.3 Testing responsibilities

The DM manufacturer is responsible for performing reliability qualification testing.

The testing detailed in this standard shall be performed by the DM manufacturer. Additional testing may be specified in the detailed specification.

5.4 Tests

5.4.1 Thorough characterization

A thorough characterization of the product for its performance (may be beyond those in the performance specifications) and overall operating conditions (may be beyond those in the operating condition specifications) shall be performed. The data shall be collected and analysed (minimal for the mean and standard deviation), and be available for review.

5.4.2 Reliability qualification of components, parts and interconnections

All components, parts, and interconnections used to build DMs shall be qualified according to the appropriate IEC standards for each of them. The components may include, but are not limited to, variable optical attenuators (VOAs), taps/splitters, detectors, isolators, circulators, electronic components, splicing connections (including the packaging or re-coating), crystals, mirrors, prisms, etc.

If the IEC standards for the parts are under development or not yet available, the IEC standards for parts of similar failure modes and degradation mechanisms should be adopted. An analysis of similarity of failure modes and degradation mechanisms shall be provided to support the approach.

Considerations shall be given to designs that use many pieces of same parts. The failure rates of such parts may significantly contribute to the overall system failure rate or downtime. The cumulative degradation from individual parts should also be investigated. The results may require tests on additional samples or more stringent failure definitions.

Additionally, the pass/fail criteria of the part qualification shall be thoroughly examined to determine whether or not the part qualification is adequate. For an example, if several 1x2 taps are used in a series design, not only the failure rate but also the degradation is multiplied (i.e. 0,5 dB pass/fail criterion is multiplied), which may not be acceptable. The pass/fail criterion of the parts commonly defined as 0,5 dB changes in insertion loss is much too loose for the needs of a product such as a DM. The assessment of tighter criteria shall be carried out and the qualification status justified.

5.4.3 Reliability qualification of DM assembly process

Fibre routing and component mounting are both important module assembling processes, and they can be significant failure rate contributors if they are not done properly. Their designs and processes shall be thoroughly documented and tested. Any changes shall be supported by adequate experiment data.

If the fibre routing is thoroughly documented and controlled (e.g. through performance measurements before and after routing) and the final DM is qualified, the fibre routing process can be considered as a qualified process and can be used in other similar products to produce a product that is claimed to be qualified by similarity.

5.4.4 Reliability qualification of the Design 1 DM

As described in 5.1 for Design 1, parts (components used to build a DM) are packaged separately. Their packages are usually either hermetic or moisture-resistant. They are integrated into a housing (usually non-hermetic or not moisture-resistant).

A reliability qualification procedure related to the complete DMs is described in Table 1. It gives the minimum list of tests to be performed on DMs in order to assure reliability.

For the tests, no failures are allowed. The tests can be performed sequentially or in parallel. For “operational” tests, relevant parameters should be monitored during the test.

On the basis of the reliability assurance required for the reliability tests for the DM internal black boxes, the sampling level is generally low (for example a few samples for each DM type).

In some specific cases the use of adhesives in the DM can be considered as a critical process and shall require separate qualification. Depending on the possible function of the adhesive (mechanical anchoring, splice protection, index matching, etc.), the different failure modes shall be addressed and supported by reliability/qualification data.

The main point in the reliability qualification of the Design 1 DMs is to ensure that the reliability of each part is not degraded in the manufacturing process used.

Table 1 – Minimum list for tests required on Design 1 DMs

Test		Condition	Duration	Samples
Active high temperature aging		85 °C	2 000 h	3
Operational temperature cycling		$T_{\text{op, min}}/T_{\text{op, max}}$ >1 °C/min	100 cycles	3
Non-operational mechanical test	Drop (impact) [a]	100 mm height drop for <10 kg, 75 mm drop for 10 kg – 25 kg	See table below	3
	Vibration [b]	10 Hz to 55Hz, 1,52 mm, 1 octave/min	2 h per direction	3
	Pull	5/10/100 N [c]	See table below	3
Operational shock [d]		400 m/s^2, 5ms for +/- z-axis, 200 m/s^2, 5ms for +/- x-axis, 100 m/s^2, 5 ms for +/- y-axis	3 times/direction	3
Operational vibration [d]		50 Hz to 500 Hz, 20 m/s^2 for z-axis, 10 m/s^2 for x-axis, 5 m/s^2 for y-axis	2 sweeps/direction	3

NOTE A reference to the temperature cycle test method is provided in Clause A.3.

[a] Mechanical test: Impact (drop) (IEC 61300-2-12 for drop)

Mass kg	Drop height mm
0 to < 10	100
10 to < 25	75

[b] Mechanical test: vibration(sinusoidal, IEC 61300-2-1).

[c] Pigtail testing (pull test). The first figure in each row is the outer diameter of the buffered or cabled fibre to which the specified test conditions apply.

Cable retention (pull)	2 mm: 20 N to100 N, 3 times, 5 s pulls 900 µm 10 N, 3 times, 5 s pulls 250 µm: 5 N, 3 times, 5 s pulls	IEC 61300-2-4

[d] The directions of the x, y and z axes are defined by mounting direction to a board in a equipment (x-axis: the direction which is according to the front and back of the board to be mounted when the board is installed in a piece of equipment; y-axis: the direction which is according to the gravity (up and down) of the board to be mounted when the board is installed in a piece of equipment; z-axis: the direction which is perpendicular to the board to be mounted.) If a tester cannot define the mounting direction, the test shall be carried out in the most severe conditions for all directions.

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

Aspects of the test conditions not provided in the present standard are given in the relevant detail specifications.

5.4.5 Reliability qualification of the Design 2 DM

A reliability qualification procedure related to design 2 DMs is described in Table 2. In this DM design, Design 2, not all parts can be effectively tested by themselves (see 4.3). Therefore, many of the long-term environmental tests can only be effectively tested and qualified in the DM final product assembly level.

For the test, no failures are allowed. The tests can be performed sequentially or in parallel. For "operational" tests, relevant parameters should be monitored during the test.

For example, some of the parts may have been qualified by the damp heat test but others may not pass the damp heat test as required for telecommunications applications. Therefore, the DM units with all the parts assembled shall be tested in damp heat conditions. This may seem redundant, but it is necessary.

Table 2 – Minimum list for tests required on Design 2 DMs

Test		Condition	Duration	Samples
Active high temperature aging		85 °C	2 000 h	3
Operational temperature cycling		$T_{op, min}/T_{op, max}$ >1 °C/min	100 cycles	3
Damp heat		85 °C/85 % RH [a]	500 h	3
Non-operational mechanical test	Drop (impact) [b]	100 mm height drop for <10 kg, and 75 mm drop for 10 kg – 25 kg	See table below	3
	Vibration [c]	10 Hz to 55 Hz, 1,52mm,1 octave/min	2 h per direction	3
	Pull [d]	5/10/100 N	See table below	3
Operational shock [e]		400 m/s^2, 5ms for ± z-axis, 200 m/s^2, 5ms for ± x-axis, 100 m/s^2, 5ms for ± y-axis	3 times/direction	3
Operational vibration [e]		50 Hz to 500 Hz, 20 m/s^2 for z-axis 10 m/s^2 for x-axis 5 m/s^2 for y-axis	2 sweeps/direction	3
Hermeticity (checked before and after liquid-to-liquid thermal shock)		ΔT = 100 °C	15 cycles	3 dummy box

NOTE A reference to the temperature cycle test method is provided in Clause A.3.

[a] Damp heat: the damp heat test at 85 °C/85 % RH for 100 h has been advocated by some manufacturers. These test conditions may be used. Otherwise, the damp heat test at 40 °C/93 % RH for a much longer duration may be used with the actual duration to be determined by the acceleration factor.

[b] Mechanical test: impact (IEC 61300-2-12).

Mass kg	Drop height mm
0 to <10	100
10 to <25	75

[c] Mechanical test: vibration (sinusoidal, IEC 61300-2-1).

[d] Pigtail testing (pull test). The first figure in each row is the outer diameter of the buffered or cabled fibre to which the specified test conditions do apply.

Cable retention (pull)	2 mm: 20 N to100 N, 3 times, 5 s pulls 900 µm: 10 N, 3 times, 5 s pulls 250 µm: 5 N, 3 times, 5 s pulls	IEC 61300-2-4

[e] The direction of the x, y and z axes are defined by mounting direction to a board in a piece of equipment (x-axis: the direction which is according to the front and back of the board to be mounted when the board is installed in a piece of equipment; y-axis: the direction which is according to the gravity (up and down) of the board to be mounted when the board is installed in a piece of equipment; z-axis: the direction which is perpendicular to the board to be mounted.) If a tester cannot define the mounting direction, the test shall be done in the most severe conditions for all directions.

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

Aspects of the test conditions not provided in the present standard are given in the relevant standards.

5.4.6 Pass/fail criteria

It should be noted that the commonly used failure criterion of a drift of higher than 0,5 dB in insertion loss (IL) is a guideline. For DWDM DMs, such as wavelength blockers, centre wavelength drift shall be defined as a failure criterion. The actual and practical criteria should be developed based on the degradation allowed for the expected life of the product. An example is provided below to illustrate the determination.

EXAMPLE:

- The acceleration factor of the testing condition to the operating condition is 50.
- The beginning-of-life parametric measurement is 1,0 dB below the end-of-life specification.
- Assume the expected life is 20 years.
- Allowed degradation for a 2 000 h testing is: (1,0*50*2 000)/(20*365,25*24) = 0,57 dB.
- Note that IL is not the only parameter considered for pass/fail; other parameters are included.

5.5 Reliability assessment procedure

5.5.1 Analysis of reliability results

The DM customer/SS shall have a procedure to analyse and verify reliability claims of a DM manufacturer. In particular, the procedure should include the analysis of

- life test data for the complete dynamic module,
- life test data for internal parts,
- environmental test results.

The analysis of results leads to reporting the reliability parameters of the DM for each type of device or sub-system. Minimum reliability parameters shall be presented as in Table 4 (see below).

5.5.2 Reliability calculations

A reliability prediction regarding the complete DM is provided by the DM manufacturer, based on the failure rates (in FIT “failure in time”) of the internal black boxes composed of the DM (Design 1) or based on the data for the complete DM (Design 2).

The failure rates of the internal black boxes shall be given by the DM manufacturer taking into account the basic values issued from the cumulated component-hours issued from the different parts included in DM. The calculations for each internal black box shall be based on the current standards regarding reliability calculations.

The reliability calculations will also include the wear-out failures. The FIT figures given for each internal black box shall take into account all expected failure modes.

The FIT figures of the internal black boxes shall be combined to give the failure rate of the Design 1 DM as explained in Table 3.

Table 3 – Failure rate of parts

Element	Number of elements	Measured value (UCL 95 %)
Splice	n_2	A_2 FIT (random failure)
Connector	n_3	A_3 FIT (random failure)
Electronics	n_4	A_4 FIT (random failure)
Active component type 1	$n_{(4+1)}$	$A_{(4+1)}$ FIT (random and wear-out failure)
Active component type 2	$n_{(4+2)}$	$A_{(4+2)}$ FIT (random and wear-out failure)
……………………………………….		……………………………………………….
Active component type m	$n_{(4+m)}$	$A_{(4+m)}$ FIT (random and wear-out failure)
Other internal component type 1	$n_{(4+m+1)}$	$A_{(4+m+1)}$ FIT (random failure)
Other internal component type 2	$n_{(4+m+2)}$	$A_{(4+m+2)}$ FIT (random failure)
……………………………………….		……………………………….
Other internal component type h	$n_{(4+m+h)}$	$A_{(4+m+h)}$ FIT (random failure)
Passive optical component type 1	$n_{(4+m+h+1)}$	$A_{(4+m+h+1)}$ FIT (random failure)
Passive optical component type 2	$n_{(4+m+h+2)}$	$A_{(4+m+h+2)}$ FIT (random failure)
……………………………………….		……………………………….
Passive optical component type k	$n_{(4+m+h+k)}$	$A_{(4+m+h+k)}$ FIT (wear-out failure)
Fibre routing		
Optical component attachment	$n_{(4+m+h+k)}$	$A_{(4+m+h+k)}$ FIT
Any other failure modes identified in FMECA	$n_{(4+m+h+k)}$	$A_{(4+m+h+k)}$ FIT
Total failure rate		$\sum_i A_i * n_I$
NOTE n_i is the number of components of each type included in the DM.		

5.5.3 Reliability qualification test methods

Table 4 shows a list of normative references relevant reliability qualification tests and test conditions for constituting components used for DMs.

Table 4 – Relevant list of IEC reliability test methods for optical components

Constituting components	IEC reference (reliability qualification document number)
Passive optical components	IEC 62005-9-1
Optical connectors	IEC TR 62005-9-2
Active optical components	IEC series 62572

6 Guidance – FMEA and qualification-by-similarity

It is worth emphasizing that the reliability assessment or qualification tests shall be based on the degradation mechanisms and failure modes. The appropriate accelerated tests can be developed once the degradation mechanisms, failure modes, and their acceleration factors are understood. To begin with, the failure mode and effects analysis (FMEA) should be developed. A set of reliability tests should be planned and conducted as the result of FMEA. The testing results can be used to develop additional tests or refined tests to better understand the degradation mechanisms or develop the acceleration models.

Where a range of dynamic modules is produced by a DM manufacturer, there may be some significant 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 sometimes have a major impact on reliability, whilst not being apparent during quality assessment.

As a minimum, FMEA shall be carried out for all varieties of products that are considered “similar” and claimed to be “qualified” by “similarity”. FMEA shall be carried out thoroughly in order to be an effective tool to consider “qualified-by-similarity”. Its thoroughness can be checked against the failure mode analysis (FMA), based on manufacturing drop-out and customer returns.

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

Annex A
(informative)

Reliability test items and their conditions

A.1 General

This annex provides information on reliability test items and conditions for DMs. The tester can select reliability test items and conditions by referring to the following.

A.2 Mechanical environment tests

Table A.1 shows the severity of test items for the mechanical environmental tests. For a dynamic module with moving parts, such as MEMS mirrors, it is strongly recommended to test operating mechanical shock and vibration. Operating mechanical shock and vibration tests are carried out by monitoring the performance of dynamic modules during the tests. The transportation vibration and handling drop test should be carried out as packed modules.

Table A.1 – Mechanical environmental tests and severity

Groups	Test items	Severity	References
Mechanical shock	Mechanical shock (operating)	400 m/s^2, 5 ms for ± z-axis 200 m/s^2, 5 ms for ± x-axis 100 m/s^2, 5 ms for ± y-axis 3 times per each direction	IEC 62343-6-5
Vibration	Mechanical vibration (operating)	50 Hz – 500 Hz 20 m/s^2 for z-axis 10 m/s^2 for x-axis 5 m/s^2 for y-axis 1 octave/min 2 sweeps per each direction	IEC 62343-6-5
Mechanical shock/impact	Mechanical shock (components) (non-operating)	5 000 m/s^2, 3 axes, 2 impacts/direction (12 impacts total) Nominal 1 ms, half sine pulse (weight: ≤ 0,125 kg)	GR-1209, IEC 61753-1, IEC 61300-2-9
	Mechanical shock (module) (non-operating)	2 000 m/s^2, 3 axes, 2 impacts/direction (12 impacts total), Nominal 1,33 ms, half sine pulse (weight: > 0,125 and ≤ 0,225 kg)	GR-1209, IEC 61753-1, IEC 61300-2-9
		500 m/s^2, 3 axes, 2 impacts/direction (12 impacts total) Nominal 5 ms, half sine pulse (weight: >0,225 and≤ 1 kg)	GR-1209, IEC 61753-1, IEC 61300-2-9
	Unpacked drop (non-operating)	100 mm height for ≤10 kg weight 75 mm height for >10 kg and ≤ 25 kg weight	GR-63
Mechanical vibration	Vibration (non-operating)	10 Hz – 55 Hz, 1,52 mm amplitude, 3 axes (20 min/axis) for 1 h	GR-1209
	Vibration (non-operating)	10 Hz – 5 Hz, 0,75 mm amplitude, 3 axes, 1 octave/min, 15 sweeps per direction	IEC 61753-1 IEC 61300-2-1
Transportation mechanical impact/vibration	Transportation vibration – packed (non-operating)	5 Hz – 20 Hz, 0,01 g^2/Hz, 20 – 200 Hz, –3 dB/octave	GR-63
	Handling drop (non-operating)	1 m height for ≤10 kg weight	GR-63

A.3 Temperature and humidity environmental tests

Table A.2 shows the severity of test items for temperature and humidity environmental tests. These kinds of tests are most common for design verification and reliability. For hermetically sealed packaged modules, it may be possible to omit damp heat and high humidity tests. For half-sealed (resin-sealed) modules, it should be noted that test modules may absorb moisture. For hermetically sealed packaged modules, it is recommended to carry out an RGA (residual gas analysis) test.

Table A.2 – Temperature and humidity tests and severity

Groups	Test items	Severity	References
High temperature	High temperature (non-operating)	60 °C ±2 °C, 96 h	IEC 61753-1 cat C, IEC 61300-2-18
Low temperature	Low temperature (non-operating)	–10 °C ±2 °C, 96 h	IEC 61753-1 cat C, IEC 61300-2-17
Temperature cycling	Temperature cycling (non-operating)	–40 °C to 70 °C, 10 cycles, dwell time: 12 min, ramp rate: 1 °K /min	GR-1209
Temperature cycling	Change of temperature (operating)	–10 °C ±2 °C to 60 °C ±2 °C, duration time: 60 min, 1 °K /min changing rate, 5 cycles	IEC 61753-1 cat C, IEC 61300-2-22
	DWDM temperature effect (operating)	–10 °C to 60 °C, dwell time: 30 min	GR-1209
Temperature shock	Low temperature thermal shock (non-operating)	30 °K/h to –40 °C, –40 °C for 72 h, 5 min to RT	GR-63
	High temperature thermal shock (non-operating)	30 °K/h to 70 °C, 70 °C for 72 h, 5 min to RT	GR-63
Damp heat	Temperature humidity aging (non-operating)	75 °C, 90 % RH, 168 h	GR-1209
	Damp heat steady state (non-operating)	40 °C ±2 °C, 93 % $^{+2}_{-3}$ %, 96 h	IEC 61753-1 cat C, IEC 61300-2-19
	High relative humidity (non-operating)	40 °C, 93 %, 96 h	GR-63
	Damp heat steady state (non-operating)	30 °C, 80 %, 96 h	JIS C 5901
Temperature humidity cycling	Temperature humidity cycling (operating)	–10 °C to 60 °C, humidity from 20 % RH to 85 % RH	GR-1209

A.4 Electromagnetic compatibility tests

Table A.3 shows test items and severity of electromagnetic compatibility tests. For the dynamic modules which use an LCD (liquid crystal device) as driving engine, an alternative wave may be used by electrical driving voltage. A DC/AC convertor circuit may have an impact on ESD and so on. For the dynamic module using an electrostatic MEMS engine inside, a high voltage up-convertor circuit may be mounted. It is recommended to carry out ESD testing when the electrical power supplying circuit is inside.

Table A.3 – Electromagnetic compatibility test items and their severities

Groups	Tests	Severity	References
Electromagnetic interference	Electromagnetic interference (non-operating)	Class B	FCC Part 15
		Class B	CISPR 22
		Class B	EN 55022
		Class B + α (original requirement)	FCC Part 15
		Class B + α (original requirement)	CISPR 22
		Class B + α (original requirement)	EN 55022
	Electromagnetic interference (non-operating)	Class A (non-residential) electromagnetic emissions immunity criteria in Clause 3 of GR-1089:2011	GR-1312, GR-1089
Electrostatic discharge	Electrostatic discharge (non-operating)	Contact discharge: 8 kV Air discharge: 15 kV	IEC 61000-4-2, Level 4
		Contact discharge: 6 kV Air discharge: 8 kV	IEC 61000-4-2, Level 3
	Electrostatic discharge (non-operating)		TR-NWT-000870
Electromagnetic immunity	Electromagnetic immunity (non-operating)	80 MHz – 1 000 MHz, 10 V/m	IEC 61000-4-3, Level 3
		80 MHz -1 000 MHz, 3 V/m	IEC 61000-4-3, Level 2
Electromagnetic fast transient/burst immunity test	Electromagnetic fast transient/burst immunity test (non-operating)		IEC 61000-4-4, Level 4
			IEC 61000-4-4, Level 3
			IEC 61000-4-4, Level 2
			IEC 61000-4-4, Level 1
Surge	Surge (non-operating)		IEC 61000-4-5
Immunity to conducted disturbances	Immunity to conducted disturbances (non-operating)		IEC 61000-4-6
Grounding	Grounding (non-operating)		GR-1089, Chapter 9

A.5 Fibre integrity tests

Table A.4 shows test items and severity of fibre integrity tests. These kinds of tests are common for pigtailed modules. It should be noted that some tests require monitoring during the test. It is recommended to consider mounting methods and procedures when selecting test items.

Table A.4 – Fibre integrity test items and their severities

Groups	Tests	Severities	References
Cable retention	Cable retention (non-operating)	0,45 kgf for coated fibre, 5 s, 3 times 0,45 kgf for tight buffer, 5 s, 3 times 1 kgf for loose buffer, 5 s, 3 times 1 kgf for reinforced, 5 s, 3 times	GR-1209
	Fibre cable retention (operating)	2 N for primary coated 5 N for secondary coated 10 N for reinforced 120 s duration for 10 N, 60 s duration for 2 N and 5 N	IEC 61753-1, cat C, IEC 61300-2-4
Fibre flex	Fibre flex (non-operating)	0,45 kgf, 30 cycles for coated, tight buffer, loose buffer, 0,45 kgf, 300 cycles for reinforced	GR-1209
	Fibre flexing (operating)	2 N for reinforced, ± 90 °, 30 cycles	IEC 61753-1, cat C, IEC 61300-2-44
Fibre twist	Fibre twist (non-operating)	0,45 kgf 10 cycles for coated, tight buffer, loose buffer, reinforced.	GR-1209
	Torsion/twist (non-operating)	5,0 N at 0,1 N/s for reinforced 2,0 N at 0,1 N/s for primary and secondary coated 10 cycles ±180 °	IEC 61753-1, cat O, IEC 61300-2-5
Fibre side pull	Fibre side pull (non-operating)	0,23 kgf 90 ° 5 s, 2 directions for coated, tight buffer, 0,45 kgf, 90 °, 5 s for loose buffer, reinforced	GR-1209
	Static side load (operating)	1 N for 1 h for reinforced cables, 0,2 N for 5 min for secondary coated fibres, two mutually perpendicular directions	IEC 61753-1, cat C, IEC 61300-2-42

Bibliography

IEC 60050-731, *International Electrotechnical Vocabulary – Chapter 731: Optical fibre communication*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61291-5-2, *Optical amplifiers – Part 5-2: Qualification specifications – Reliability qualification for optical fibre amplifiers*

IEC 61300-2-5, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-5: Tests – Torsion*

IEC 61300-2-9, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-9: Tests – Shock*

IEC 61300-2-42, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-42: Tests – Static side load for connectors*

IEC 61300-2-44, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-44: Tests – Flexing of the strain relief of fibre optic devices*

IEC 61753-1, *Fibre optic interconnecting devices and passive components performance standard – Part 1: General and guidance for performance standards*

IEC TR 61931, *Fibre optic – Terminology*

IEC 62343-6-5, *Dynamic modules – Part 6-5: Design guide – Investigation of operating mechanical shock and vibration tests for dynamic devices*

CISPR 22, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

EN 55022, *Information Technology Equipment – Radio disturbance characteristics – Limits and methods of measurement*

FCC Radio 47, Part 15, *Communications equipment Computer technology*

Telcordia GR-63, *NEBS(TM) Requirements: Physical Protection*

Telcordia GR-1089:2011, *Electromagnetic Compatibility and Electrical Safety – Generic Criteria for Network Telecommunications Equipment*

Telcordia GR-1209, *Generic Requirements for Passive Optical Components*

Telcordia GR-1221, *Generic Reliability Assurance Requirements for Passive Optical Components*

Telcordia GR-1312, *Generic Requirements for Optical Fiber Amplifiers and Proprietary Dense Wavelength-Division Multiplexed Systems*

Telcordia TR-NWT-000870, *Electrostatic Discharge Control in the Manufacture of Telecommunications Equipment*

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