

# INTERNATIONAL STANDARD

CONSOLIDATED VERSION

**Optical amplifiers -  
Part 5-2: Qualification specifications - Reliability qualification for optical fibre  
amplifiers**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**Optical amplifiers -  
Part 5-2: Qualification specifications -  
Reliability qualification for optical fibre amplifiers**

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 61291-5-2 edition 2.1 contains the second edition (2017-01) [documents 86C/1376/CDV and 86C/1426/RVC], its corrigendum 1 (2019-05) and its amendment 1 (2026-02) [documents 86C/2005/FDIS and 86C/2010/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 61291-5-2 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition published in 2002. It constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) removal of the contents on the relating quality management system from scope, terms and definitions, and the reliability requirements;
- b) moving fit-rate calculation to Annex B (informative);
- c) change of requirements for shock test;
- d) amendment of abbreviations related to changes a) and b).

The text of this International Standard is based on the following documents:

CDV	Report on voting
86C/1376/CDV	86C/1426/RVC

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

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

A list of all parts in the IEC 61291 series, published under the general title *Optical amplifiers*, can be found on the IEC website.

The committee has decided that the contents of this document and its amendment will remain unchanged until the stability date indicated on the IEC website under [webstore.iec.ch](http://webstore.iec.ch) in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

## 1 Scope

This part of IEC 61291 applies to optical amplifiers (OAs) and optically amplified, elementary sub-systems for terrestrial applications, using active fibres (optical fibre amplifiers (OFAs)) containing rare-earth dopants, which are commercially available.

The black box approach is used in this document. The black box approach is adopted in order to give product specifications which are independent of OA implementation details. For reliability qualification purposes, some information about the internal components is needed; these internal parts are themselves treated as black boxes. This document gives requirements for the evaluation of OA reliability by combining the reliability of such internal black boxes.

The object of this document is to specify the minimum list of reliability qualification tests, requirements on failure criteria during testing and on reliability predictions, and give the relevant normative references to establish a standard method for the assessment of the reliability of OFA devices and sub-systems in order to minimize risks and to promote product development and reliability qualification.

## 2 Normative references

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

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

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

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

IEC 60068-2-21, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-31, *Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 61291-1, *Optical fibre amplifiers – Part 1: Generic specification*

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

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

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*

### 3 Terms, definitions and abbreviated terms

#### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61291-1, IEC 60050-731 and the following apply.

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

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

##### 3.1.1 failure

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

##### 3.1.2 OFA manufacturer OFAM

manufacturer who provides optical fibre amplifier (OFA) devices or subsystems meeting the requirements of the applicable product specification (PS)

Note 1 to entry PS includes the reliability requirement.

#### 3.2 Abbreviated terms

EDFF	erbium doped fluoride fibre
EDSFA	erbium doped silica fibre amplifier
EDTF	erbium doped tellurite fibre
FIT	failure in time
FFS	for further study
OA	optical amplifier
OFA	optical fibre amplifier
OFAM	optical amplifier manufacturer
OFAM	optical fibre amplifier manufacturer
Pdff	praseodymium doped fluoride fibre
PS	product specification
RH	relative humidity
DFF	thulium doped fluoride fibre
UCL	upper confidence level

### 4 Reliability requirements

#### 4.1 Tests

##### 4.1.1 General

An optical fibre amplifier (OFA) device or sub-system is an assembly of various parts and components of different nature. A main point in the reliability testing of the OFA device or sub-system is to ensure the reliability of each part and basic manufacturing process used and to

provide a route that may result in an understanding of design margins. For the purpose of this document, each internal part shall be seen as a black box.

This document is based on the assumption that the reliability of an optical amplifier (OA) can be evaluated with sufficient confidence from the failure in time (FIT) rates of its internal black boxes when the assembly process of the constituents has been qualified.

The procedures to qualify the assembly process are described in 4.1.3.

The reliability assurance is confirmed by the test procedure described in 4.1.4 carried out on the OFA device or sub-system as a whole.

The basic parts usually constituting an OFA are listed below:

- passive optical components;
- opto-electronic components;
- doped fibres or doped fibre modules;
- optical connectors;
- electronics;
- others (to be specified);
- mechanical packaging.

The OFA manufacturer (OFAM) should declare the number and type of the internal black boxes constituting the OFA and give the failure rates (in FIT) for each of them.

The OFA failure rate should be calculated by suitably combining the FIT rates of its internal parts, as described in Annex B.

#### 4.1.2 Reliability qualification of components

Table 1 and Table 2 give the minimum list of tests to be performed on the various parts, where used, constituting the OFA in order to guarantee the claimed reliability level. Normative references for tests and test conditions are given in Annex A.

**Table 1 – Minimum test list for passive optical components, pump laser modules, monitor diode modules and optical connectors**

Component	Reference
Pump laser diode	IEC 62572-3 (informative)
Photo diode	To be defined
Passive optical components	IEC 62005-9-1
Optical connectors	IEC 62005-9-2
Variable optical attenuators	To be defined

**Table 2 – Minimum test list for doped fibre**

Test
Proof test
Hydrogen aging
Fibre coating strip force (for non-hermetic fibre only)

A set of test conditions suitable to the test lists in Table 1 and Table 2 to assess the reliability of OFA components (seen as black boxes) is given for reference in Annex A. These test conditions specify the common practice in the OFA manufacturing industry.

#### 4.1.3 Reliability qualification of the OFA assembly process

Fibre arrangement and assembly of the optical and electrical components are very important aspects for assessing the reliability of an OFA. In particular, the fibre winding and splice process is one of the most critical steps in the OFA assembly process.

The splice process shall be qualified according to the relevant fibre and coating material.

Table 3 indicates the tests required on splices.

**Table 3 – Tests required for splices**

Tests	Conditions	Reference
High temperature storage	+85 °C 2 000 h	IEC 60068-2-2, Tests B
Change of temperature (Thermal cycling) <sup>a</sup>	-40 °C /+85 °C 2 °C/min <i>Q</i> = 100 cycles <i>I</i> = 500 cycles	IEC 60068-2-14
Damp heat <sup>b</sup>	40 °C 93 % RH 500 h	IEC 60068-2-78
	85 °C 85 % RH 500 h	
Shock	1 000 m/s <sup>2</sup> 6 ms 6 times/axis	IEC 60068-2-27
Vibrations	5 Hz to 50 Hz, 15 m/s <sup>2</sup> 50 Hz to 500 Hz, 30 m/s <sup>2</sup> 3 axis Duration 15 sweeps	TIA 455-11
Robustness test (Pull test)	5 N 10 s	IEC 60068-2-21
<p><sup>a</sup> <i>Q</i>: data for qualification, <i>I</i>: data for information.</p> <p><sup>b</sup> Damp heat: the damp heat test at 85 °C 85 % RH has been advocated by some manufacturers, as justified by observations of conditions within peculiar environments. These test conditions shall be used for splices within OFAs to be deployed in very harsh environments (such as optical fibre communication systems). Otherwise, the damp heat test at 40 °C 93 % RH shall be used.</p>		

The number of samples is to be agreed between customer and supplier according to the level of confidence and the level of reliability required.

#### 4.1.4 Reliability qualification of the OFA device or sub-system

A reliability qualification procedure related to the complete OFA device or sub-system is described in Table 4. It gives the minimum list of tests to be performed on OFA devices and sub-systems in order to assure reliability. Normative references, where tests and test conditions are specified, are given in Annex A.

The purpose of the testing is to assess the prediction of the failure rate of the complete OFA performed according to the procedure of 4.1.2.

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