

This is a preview - click here to buy the full publication



IEC/TR 62547

Edition 2.0 2013-05

# TECHNICAL REPORT



---

**Guidelines for the measurement of high-power damage sensitivity of single-mode fibre to bends – Guidance for the interpretation of results**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

PRICE CODE

W

---

ICS 33.180.10

ISBN 978-2-83220-801-4

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	4
1 Scope.....	6
2 Normative references .....	6
3 Background .....	7
4 Test procedures .....	9
4.1 Safety.....	9
4.1.1 Safety issues .....	9
4.1.2 Eye safe working .....	9
4.1.3 Risk of fire/flame .....	9
4.1.4 Risk of atmospheric pollution from coating by-products.....	9
4.1.5 Risk of fibre fuse initiation .....	9
4.1.6 Risk of damage to downstream components .....	10
4.1.7 Risk avoidance .....	10
4.2 General .....	10
4.3 Apparatus.....	10
4.3.1 Light source.....	10
4.3.2 Isolator .....	10
4.3.3 Bend jig .....	11
4.3.4 Receiver .....	11
4.3.5 Attenuator .....	11
4.3.6 Computer .....	11
4.3.7 Camera .....	11
4.3.8 Thermal imaging camera .....	11
4.3.9 Oven .....	11
4.3.10 Sample.....	12
4.4 Test method 1 – Failure time characterization as a function of the launch power and bend conditions (bend angle and diameter) .....	12
4.4.1 Description and procedure.....	12
4.4.2 General comments and conclusions on test method 1.....	13
4.4.3 Reported items for test method 1 .....	14
4.5 Test method 2 – Equilibrium temperature measurement .....	14
4.5.1 General .....	14
4.5.2 Coating heating measurements and power lost at bend .....	16
4.5.3 Analysis – test method 2: equilibrium temperature .....	17
4.5.4 Test conditions for test method 2 .....	18
4.5.5 Conclusions on test method 2 .....	19
4.5.6 Reported items for test method 2 .....	19
5 Conclusions.....	20
Annex A (informative) Robustness of fibres against damage from exposure to high power at bends .....	21
Bibliography.....	39
Figure 1 – Example of experimental layout.....	11
Figure 2 – Damage results for fibre ‘G’.....	13
Figure 3 –Example of time evolution of catastrophic high-power loss and related maximum temperature reached by the coating near to the top of the bent fibre (apex) .....	15

Figure 4 – Sample FLIR camera output of the fibre bent under high power .....	16
Figure 5 – Dependence of the coating equilibrium temperature as a function of launched power and bend diameter for an IEC B1.2/ITU-T G.654 single-mode fibre (see reference [10]) .....	16
Figure 6a – Calculated from experimental test data at 1 360 nm .....	18
Figure 6b – Extrapolated for 1 550 nm .....	18
Figure 6c – Extrapolated for 1 625 nm .....	18
Figure 6 – Maximum safe powers for 25 year life time as a function of bend radius enabling a safe coating temperature of ~80 °C for four single-mode fibre (sub-) categories .....	18
Figure A.1 – Clamping arrangements for high-power damage testing in 180° bends.....	23
Figure A.2 – Clamping arrangement for high-power damage testing in 90° bends .....	23
Figure A.3 – Typical R1 failure characteristics with a loss of greater than 10 dB .....	24
Figure A.4 – Typical R2 failure characteristics .....	24
Figure A.5 – A schematic illustration of the three regimes .....	24
Figure A.6 – Monitor signal changes – Typical for an R1 failure .....	25
Figure A.7 – Monitor signal changes – Typical for an R2 failure .....	25
Figure A.8 – Damage results for fibre sample ‘D’ .....	26
Figure A.9 – High-power damage results at 90° and 180° for fibre ‘D’ .....	26
Figure A.10 – Time to failure versus bend diameter at different launched powers .....	27
Figure A.11 – Bend loss performance at 180° (and 90° for comparison) for fibre ‘D’.....	28
Figure A.12 – Power limitation for primary coated fibre .....	28
Figure A.13 – Comparison of power limitation for primary and secondary coated fibre ‘D’ .....	29
Figure A.14 – Maximum optical power ensuring a 25 year lifetime and 180° bend loss versus bend diameter (from reference [10]).....	30
Figure A.15 – Maximum optical power ensuring a 25 year lifetime versus 180° bend loss.....	30
Figure A.16 – 180° 2-point OSA bend loss for fibre ‘D’ .....	32
Figure A.17 – 180° 2-point bend loss at 1 480 nm for fibre ‘D’ .....	32
Figure A.18 – 2-point bend loss for fibre ‘D’ at various angles .....	33
Figure A.19 – 180° 2-point bend loss at 1 480 nm for a range of fibres .....	34
Figure A.20 – Time to failure versus inverse of equilibrium temperature using an IEC B1.2/ITU-T G.654 single-mode fibre for bend diameters varying from 4 mm to 10 mm and launched power in the range 0,8 W to 3,2 W.....	35
Figure A.21 – Effect of baking primary coated fibre ‘C’ (reference [15]) in an oven at constant temperature .....	35
Figure A.22 – Time to failure for different coatings as a function of bend radius .....	37
Table A.1 – Dependence of high-power damage on power entering coating .....	37

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

### **GUIDELINES FOR THE MEASUREMENT OF HIGH-POWER DAMAGE SENSITIVITY OF SINGLE-MODE FIBRE TO BENDS – GUIDANCE FOR THE INTERPRETATION OF RESULTS**

#### 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.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC 62547, which is a technical report, has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition published in 2009, and constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

- updates related to B6 (bend-insensitive) category single-mode fibres);
- update to analysis for test method 2: Maximum temperature specification.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
86A/1494/DTR	86A/1508/RVC

Full information on the voting for the approval of this technical report 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.

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.

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

**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.**

# **GUIDELINES FOR THE MEASUREMENT OF HIGH-POWER DAMAGE SENSITIVITY OF SINGLE-MODE FIBRE TO BENDS – GUIDANCE FOR THE INTERPRETATION OF RESULTS**

## **1 Scope**

This technical report describes two methods for the measurement of the sensitivity of single-mode optical fibres to high-power damage at bends:

- test method 1 – Failure time characterisation as a function of the launch power and bend conditions (bend angle and bend diameter);
- test method 2 – Equilibrium temperature measurement.

Results from the two methods can only be compared qualitatively.

The results in this report are predominantly on un-cabled and un-buffered fibres. Cabled and buffered fibres are expected to respond differently, because the outer layers can affect the ageing process. Note also that test method 2 testing cannot be applied to buffered or cabled fibres.

These methods do not constitute a routine test to be used in the evaluation of optical fibre.

The parameters derived from the two methods are not intended to be specified within a detailed fibre specification.

The catastrophic failure modes arising and which are described in this document in general occur at bending radii much smaller than specified in the single-mode fibre specification IEC 60793-2-50 or than would be recommended based on mechanical reliability considerations alone.

This report includes several annexes, including a discussion on the rationale for the approaches adopted, metrics for assessment, guidance, examples and some conclusions from initial studies.

## **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 60793-1-47, *Optical fibres – Part 1-47: Measurement methods and test procedures – Macrobending loss*

IEC 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 60825-2, *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)*

IEC 61300-2-14, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-14: Tests – High optical power*

IEC/TR 61292-4, *Optical amplifiers – Part 4: Maximum permissible optical power for the damage-free and safe use of optical amplifiers, including Raman amplifiers*