PD IEC/TR 62048:2014

BSI Standards Publication

Optical fibres — Reliability — Power law theory

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National foreword

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

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TECHNICAL REPORT

colour inside

Optical fibres – Reliability – Power law theory

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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IEC/TR 62048, which is a technical report, has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

This third edition cancels and replaces the second edition published in 2011, and constitutes a technical revision.

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

– correction to the unit of failure rates in Table 1;

– correction to the FIT equation for instantaneous failure rate [19][1] in addition to all call-outs and derivations;
– insertion of a new note about fibre length dependency of failure rates;
– addition of informative Annex A and relevant reference;
– editorial corrections of inconsistencies.

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

Enquiry draft	Report on voting
86A/1537/DTR	86A/1554/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- withdrawn,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.

1 Numbers in square brackets refer to the Bibliography.

INTRODUCTION

Reliability is expressed as an expected lifetime or as an expected failure rate. The results cannot be used for specifications or for the comparison of the quality of different fibres. This technical report develops the theory behind the experimental principles used in measuring the fibre parameters needed in the reliability formulae. Much of the theory is taken from the referenced literature and is presented here in a unified manner. The primary results are formulae for lifetime or for failure rate, given in terms of the measurable parameters. Conversely, an allowed maximum service stress or extreme value of another parameter may be calculated for an acceptable lifetime or failure rate.

For readers interested only in the final results of this technical report – a summary of the formulae used and numerical examples in the calculation of fibre reliability – Clauses 6 and 7 – are sufficient and self-contained. Readers wanting a detailed background with algebraic derivations will find this in Clauses 8 to 12. An attempt is made to unify the approach and the notation to make it easier for the reader to follow the theory. Also, it should ensure that the notation is consistent in all test procedures. The Bibliography has a limited set of mostly theoretical references, but it is not necessary to read them to follow the analytical development in this technical report. Annex A introduces a statistical strength degradation (SSD) map which gives intuitive understanding of the physical meaning of the formulae appearing in Clauses 10 and 11.

NOTE Clauses 8 to 12 reference the B-value, and this is done for theoretical completeness only. There are as yet no agreed methods for measuring B, so the Bibliography gives only a brief analytical outline of some proposed methods and furthermore develops theoretical results for the special case in which B can be neglected.

OPTICAL FIBRES –

Reliability – Power law theory

1 Scope

This technical report is a guideline that gives formulae to estimate the reliability of fibre under a constant service stress based on a power law for crack growth.

NOTE Power law is derived empirically, but there are other laws which have a more physical basis (for example, the exponential law). All these laws generally fit short-term experimental data well but lead to different long-term predictions. The power law has been selected as a most reasonable representation of fatigue behaviour by the experts of several standard-formulating bodies.

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 60793-1-30, *Optical fibres – Part 1-30: Measurement methods and test procedures – Fibre proof test*

IEC 60793-1-31, *Optical fibres – Part 1-31: Measurement methods and test procedures – Tensile strength*

3 Symbols

Table 1 provides a list of symbols found in this report. Each symbol appears in the subclause(s) indicated in the final column of the table.

Table 1 – Symbols

Symbol	Unit	Name	Subclause
a	µm	Flaw depth	8.1
a_f	µm	Radius of glass fibre	11.3
B	GPa^2×s	Crack strength preservation parameter or B-value	8.1
B_0	GPa^2×s	Transitional B-value at the slow-unloading/fast-unloading boundary	10.4
c	Dimensionless	Non-linearity term for stress versus strain	8.4
C	Dimensionless	Additive dimensionless proof test term or C-value	11.6
C_0	Dimensionless	Transitional value of C at the slow-unloading/fast-unloading boundary	11.6
D	Mm	Fibre-axes separation in two-point bending	11.3.3
E_0	Gpa	Zero-strain Young's modulus	8.4
F	Dimensionless	Fibre failure probability	12.1
$K_I(t)$	GPa×µm$^{1/2}$	Stress intensity factor	8.1
K_{Ic}	GPa×µm$^{1/2}$	Critical stress intensity factor	8.1