

TECHNICAL REPORT



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



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ELECTROTECHNICAL
COMMISSION

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CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope and object.....	7
2 Normative references	7
3 Abbreviated terms	8
4 Maximum transmissible optical power to keep fibres damage-free	8
4.1 General	8
4.2 Fibre fuse and its propagation	9
4.2.1 Introduction	9
4.2.2 Experiment and results	9
4.2.3 Conclusion	10
4.3 Loss-induced heating at connectors or splices.....	10
4.3.1 Introduction	10
4.3.2 Experiment on the connector	10
4.3.3 Results and considerations	11
4.3.4 Conclusion	11
4.4 Connector end-face damage induced by dust/contamination	12
4.4.1 Introduction	12
4.4.2 Test setup	12
4.4.3 Measurements	12
4.4.4 Test on clean connectors.....	12
4.4.5 Test on connectors contaminated with skin grease	12
4.4.6 Test on connectors contaminated with dust	13
4.4.7 Test on connectors contaminated with metal dust.....	13
4.4.8 Conclusion	14
4.5 Fibre-coat burn/melt induced by tight fibre bending	14
4.6 Summary of the fibre-damage experiments.....	15
5 Maximum transmissible optical power to keep eyes and skin safe	16
5.1 Maximum permissible exposure (MPE) on the surface of eye and skin	16
5.2 Maximum permissible optical power in the fibre for the safety of eye and skin	16
5.2.1 Need for APR	18
5.2.2 Wavelengths.....	18
5.2.3 Locations.....	18
5.2.4 Nominal ocular hazard distance (NOHD)	18
5.2.5 Power reduction times	18
5.2.6 Medical aspects of the safety of eyes and skin in existing standards	19
6 Maximum optical power permissible for optical amplifiers from the viewpoints of fibre damage as well as eye and skin safety	20
7 Conclusion	20
Bibliography.....	21
Figure 1 – Experimental setup for fibre fuse propagation	9
Figure 2 – Connection loss versus temperature increase	11
Figure 3 – Test setup	12
Figure 4 – Surface condition contaminated with metal filings, before the test	13

Figure 5 – Variation of the power attenuation during the test at several power input values for plugs contaminated with metal filings.....	13
Figure 6 – Polishing surface condition contaminated with metal filing, after the test.....	14
Figure 7 – Thermo-viewer image of tightly-bent SMF with optical power of 3 W at 1 480 nm	15
Figure 8 – Temperature of the coating surface of SMFs against bending with optical power of 3 W at 1 480 nm	15
Figure 9 – Maximum permissible power in the fibre against APR power reduction time	19
Table 1 – Experimental results of the threshold power of fibre fuse propagation	9
Table 2 – Measurement conditions	11
Table 3 – Examples of power limits for optical fibre communication systems having automatic power reduction to reduce emissions to a lower hazard level	17
Table 4 – Location types within an optical fibre communication system and their typical installations	18

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

OPTICAL AMPLIFIERS –

**Part 4: Maximum permissible optical power
for the damage-free and safe use of optical amplifiers,
including Raman amplifiers**

FOREWORD

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IEC 61292-4, which is a technical report, 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 2004 and constitutes a technical revision with updates reflecting new research in the subject area.

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

Enquiry draft	Report on voting
86C/889/DTR	86C/921/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.

A list of all parts of the IEC 61292 series, published under the general title *Optical amplifiers*, 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 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.

INTRODUCTION

This technical report is dedicated to the subject of maximum permissible optical power for damage-free and safe use of optical amplifiers, including Raman amplifiers. Since the technology is quite new and still evolving, amendments and new editions to this document can be expected.

Many new types of optical amplifiers are entering the marketplace and research on it is also stimulating many new types of fibre and non-fibre based optical amplifier research. With the introduction of such technologies as long-haul, 40 Gb/s, WDM transmission and Raman amplification, some optical amplifiers may involve optical pump sources with extremely high optical power – up to, possibly, several watts.

Excessively high optical power may cause physical damage to the fibres/optical components/equipment as well as present medical danger to the human eye and skin.

The possibility of fibre damage caused by high optical intensity has recently been discussed at some technical conferences. IEC technical committee 86 (Fibres optics) and subcommittee 86A (Fibres and cables) has published IEC 62547: *Guidelines for the measurement of high-power damage sensitivity of single-mode fibres to bends – Guidance for the interpretation of results*. IEC technical committee 31 (Equipment for explosive atmospheres) is also discussing the risk of ignition of hazardous environments by radiation from optical equipment.

The medical aspects have long been discussed at standards groups. IEC technical committee 76 (Optical radiation safety and laser equipment) precisely describes in IEC 60825-2 the concept of hazard level and labelling and addresses the safety aspects of lasers specifically in relation to tissue damage.

ITU-T study group 15 (Optical and other transport networks) has published Recommendation G.664, which primarily discusses the automatic laser power reduction functionality for safety.

With the recent growth of interest in fibre Raman amplifiers, however, some difficulties have been identified among optical amplifier users and manufacturers in fully understanding the technical details and requirements across all such standards and agreements.

This technical report, therefore, provides a simple informative guideline on the maximum optical power permissible for optical amplifiers.

OPTICAL AMPLIFIERS –

Part 4: Maximum permissible optical power for the damage-free and safe use of optical amplifiers, including Raman amplifiers

1 Scope and object

This part of IEC 61292, which is a technical report, applies to all commercially available optical amplifiers (OAs), including optical fibre amplifiers (OFAs) using active fibres, as well as Raman amplifiers. Semiconductor optical amplifiers (SOAs) using semiconductor gain media are also included.

This technical report provides a simple informative guideline on the threshold of high optical power that causes high-temperature damage of fibre. Also discussed is optical safety for manufacturers and users of optical amplifiers by reiterating substantial parts of existing standards and agreements on eye and skin safety.

To identify the maximum permissible optical power in the optical amplifier from damage-free and safety viewpoints, this technical report identifies the following values:

- the optical power limit that causes thermal damage to the fibre, such as fibre fuse and fibre-coat burning;
- the maximum permissible exposure (MPE) to which the eyes/skin can be exposed without consequential injury;
- the optical power limit in the fibre that causes MPE on the eyes/skin after free-space propagation from the fibre;
- the absolute allowable damage-free and safe level of optical power of the optical amplifier by comparing (a) and (c).

The objective of this technical report is to minimize potential confusion and misunderstanding in the industry that might cause unnecessary alarm and hinder the progress and acceptance of advancing optical amplifier technologies and markets.

It is important to point out that the reader should always refer to the latest international standards and agreements because the technologies concerned are rapidly evolving. In fact, the concept of hazard level and labelling is still evolving: more rigorous labelling requirements are under discussion in IEC Technical Committee 76 as of October 2008.

The present technical report will be frequently reviewed and will be updated by incorporating the results of various studies related to OAs and OA-supported optical systems in a timely manner.

2 Normative references

The following referenced documents are indispensable for the application 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 60825-1:2007, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 60825-2:2006, *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)*
Amendment 1(2006)

IEC/TR 60825-14:2004, *Safety of laser products – Part 14: A user's guide*

ITU-T Recommendation G. 664, *Optical safety procedures and requirements for optical transport systems*

3 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

ALS	automatic laser shutdown
APR	automatic power reduction
DSF	dispersion shifted fibre
LOS	loss of signal
MFD	mode field diameter
MPE	maximum permissible exposure
MPI-R	single channel receive main path Interface reference point
MPI-S	single channel source main path interface reference point
NOHD	nominal ocular hazard distance
NZ-DSF	non-zero dispersion shifted single-mode optical fibre
OA	optical amplifier
OFA	optical fibre amplifier
SMF	single mode fibre
SOA	semiconductor optical amplifier

4 Maximum transmissible optical power to keep fibres damage-free

4.1 General

The use and reasonably foreseeable misuse of high intensity optical amplifiers may cause problems in the fibre such as:

- fibre fuse and its propagation;
- heating in the splice point/connection point;
- fibre end-face damage due to dust and other contamination;
- fibre coat burning and ignition of hazardous environments due to tight fibre bending or breakage.

This clause introduces the experiments and their results concerning the above issues to give guidelines for the damage-free use of optical amplifiers. However, it must be noted that the following results are only valid under the conditions tested and that a higher power might be allowed under different conditions.

NOTE The test method for the failure time (the time until the catastrophic failure of the glass, or the catastrophic failure to the fibre coating happens) characteristics as a function of the launch power and bend conditions (bend angle and diameter) is described in IEC 62547.