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Edition 4.0 2023-01

TECHNICAL REPORT

colour inside

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



IEC TR 61292-4:2023-01(en)



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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 TR 61292-4 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics. It is a Technical Report.

This fourth edition cancels and replaces the third edition published in 2014. This edition constitutes a technical revision.

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

a) The technical information has been updated to reflect revisions of the relevant references.
b) In particular, the descriptions provided in Clause 5 and Clause 6 have been modified significantly to reflect changes in the cited references. Unnecessary formulas and explanations that overlap with the references have been removed to simplify the document.
c) New information has been added to Annex A on optical fibre burning when light enters an optical fibre with a bubble train formed by a fibre fuse.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
86C/1821/DTR	86C/1832/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in 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 document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this document 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 document is dedicated to the subject of maximally 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 is also stimulating the development of many new types of fibre and non-fibre based optical amplifiers. With the introduction of new technologies, such as long-haul, beyond 100 Gb/s, WDM transmission, digital coherent transmission and Raman amplification, some optical amplifiers employ optical pump sources with extremely high optical power – possibly up to several Watts. For example, erbium doped fibre amplifiers that provide extremely high output power are described in IEC TR 61292-8 [1][1], and Raman amplifiers in IEC TR 61292-6 [2].

Excessively high optical power can cause physical damage to the optical fibres, components and equipment, in addition to presenting a medical hazard to the human eye and skin.

The possibility of fibre damage caused by high optical intensity has been discussed at technical conferences and in technical reports for many years. The use of high intensity optical amplifiers can cause problems in optical fibres, which include fibre fuse, heating in the splice points (connection points), fibre endface damage due to dust, and fibre coat burning due to tight fibre bending. For example, IEC TR 62547 [3] provides guidelines for the measurement of high-power damage sensitivity of single-mode fibre to bends, and IEC TR 62627-01 [4] describes cleaning methods for fibre optic connectors to reduce the risk of fibre endface damage. In addition, other standard groups are discussing the risk of ignition of hazardous environments caused by high-power radiation from optical equipment.

The medical aspects of high-power optical radiation have also been addressed by standards. IEC 60825-2 defines the concept of hazard levels and corresponding labelling, which addresses the safety aspects of lasers specifically in relation to tissue damage.

In addition, IEC TR 60825-17 [5] describes safety measures to protect against effects caused exclusively by thermal, opto-mechanical and related effects in passive optical components and optical cables used in high power optical fibre communication systems. Moreover, ITU-T Recommendation G.664 [6] discusses the safety feature of automatic laser power reduction.

With the recently growing interest in high power fibre amplifiers and 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 document provides a simple informative guideline on the maximum optical power permissible for optical amplifiers for optical amplifier users and manufacturers.

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1 Numbers in square brackets refer to the Bibliography.

OPTICAL AMPLIFIERS –

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

1 Scope

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 document provides informative guidelines on the threshold of high optical power that can cause high-temperature damage of the fibre. Also discussed is optical safety for manufacturers and users of optical amplifiers by quoting parts of existing standards and agreements on eye and skin safety.

This document identifies the following values for maximum permissible optical power in the optical amplifier for damage-free and safe operation:

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

The objective of this document is to minimize potential confusion and misunderstanding in the industry that can cause unnecessary alarms and hinder the progress and acceptance of advancing optical amplifier technologies in the market.

It is important that the reader always refers to the latest international standards and agreements, because the technologies concerned are rapidly evolving.

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

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 61291-1:2018, *Optical amplifiers – Part 1: Generic specification*

3 Terms, definitions, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61291-1:2018 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

3.2 Abbreviated terms

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 fibre
OA	optical amplifier
OFA	optical fibre amplifier
OFCS	optical fibre communication system
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 can cause problems in the fibre such as

a) fibre fuse and its propagation,

b) heating in splice points/connection points,

c) fibre endface damage due to dust and other contamination, and

d) fibre coat burning and ignition of hazardous environments due to tight fibre bending or breakage.

Subclauses 4.2 to 4.5 introduce results concerning the above issues to give guidelines for the damage-free use of optical amplifiers. However, the following results are only valid under the conditions tested, and a higher power could be applied under different conditions.