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TECHNICAL REPORT

colour inside

Fibre optic active components and devices – Test and measurement procedures – Part 7: Calculation methodology of laser safety class for optical transceivers and transmitters

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FIBRE OPTIC ACTIVE COMPONENTS AND DEVICES – TEST AND MEASUREMENT PROCEDURES –

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IEC TR 62150-7 has been prepared by subcommittee 86C: Fibre optic active components and devices, of IEC technical committee 86: Fibre optics. It is a Technical Report.

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

Draft	Report on voting
86C/1934/DTR	86C/1940/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/publications.

A list of all parts in the IEC 62150 series, published under the general title *Fibre optic active components and devices – Test and measurement procedures*, 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- withdrawn, or
- revised.

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

Laser safety criteria calculations for optical transceivers and transmitters are defined in IEC 60825-1. However, the calculation methodology in IEC 60825-1 is complicated and covers a wide range of laser products. This document provides simple calculation guidelines that are tailored to transceiver and transmitter products for fibre optic telecommunication systems.

The intent of this document is to resolve possible confusion on how to handle the specifications in IEC 60825-2, which define safety criteria for Optical Fibre Communication Systems (OFCSs). In IEC 60825-1 the safety categories are called "Class n", but in IEC 60825-2 they are called "Hazard level n". As single units that are not connected to an OFCS, optical transceivers and transmitters are components, for which the specifications of IEC 60825-1 are applicable, that is the safety categories "Class n". However, when optical transceivers and transmitters are integrated in (i.e. connected to) an Optical Fibre Communication System, the specifications of IEC 60825-2 apply, which uses the safety categories "Hazard level n". Hence, when the power levels in an OFCS are examined, the "Hazard level n" categories of IEC 60825-2 apply. For the same number n, the power limits of "Hazard level n" are usually lower than the power limits of "Class n". The fact that the power limits for "Class n" and "Hazard level n" are sometimes different causes considerable confusion in the industry. This document therefore also includes Hazard level calculations, which are provided in informative Annex A.

FIBRE OPTIC ACTIVE COMPONENTS AND DEVICES – TEST AND MEASUREMENT PROCEDURES –

Part 7: Calculation methodology of laser safety class for optical transceivers and transmitters

1 Scope

This part of IEC TR 62150, which is a technical report, provides simple calculation guidelines for the laser safety class of optical transceivers and transmitters, whose baseline standard is IEC 60825-1. The calculation methodology for Class 1 and Class 1M safety levels is the main scope of this document, because most of optical transceivers and transmitters are specified for these classifications. The calculations and classifications in this document follow IEC 60825-1, which specifically advises that laser safety classifications be based on tests that consider any reasonably foreseeable single-fault condition in the application of a transceiver or transmitter. More information can be found in IEC 60825-1:2014, 5.1.

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 60825-1:2014, *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 (OFCSs)*

NOTE IEC 60825-2:2021 refers to IEC 60825-1:2014 as a normative reference.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60825-1 and IEC 60825-2 apply.

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

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

4 Calculation methodology

4.1 General

Optical transceivers and transmitters are categorized as optical components, for which the laser safety specifications are defined in IEC 60825-1. However, when the power levels in an optical fibre communication system (OFCS) are considered, into which the transceivers or transmitters are integrated, the safety specifications for OFCSs apply, which are defined in IEC 60825-2. Both standards are important for transceiver and transmitter laser safety specifications, depending on the application.

4.2 Wavelength

In IEC 60825-1 and IEC 60825-2, laser wavelengths are categorized into several ranges, as shown in Table 1, for which important parameters, such as the measurement conditions, the Accessible Emission Limits (AELs) for Class 1 and Class 1M, and the coefficients C_4, C_6 and C_7, are defined differently. The wavelength dependence of these parameters reflects the fact that the effects causing physical damage are wavelength dependent.

Table 1 – Laser wavelength categorization for each specific parameter

<table>
<tr><th>Wavelength range
nm</th><th>Condition 1, 2, 3</th><th>AEL for Class 1 / 1M</th><th>AEL for Class 1 / 1M (extended)</th><th>C_4</th><th>C_6</th><th>C_7</th></tr>
<tr><td>700 to 1 050</td><td rowspan="4">✓</td><td rowspan="4">✓</td><td>✓</td><td>✓</td><td rowspan="4">✓</td><td>✓</td></tr>
<tr><td>1 050 to 1 150</td><td rowspan="3">✓</td><td rowspan="3">✓</td><td rowspan="2">✓</td></tr>
<tr><td>1 150 to 1 200</td><td>✓</td></tr>
<tr><td>1 200 to 1 400</td><td>✓</td></tr>
<tr><td>1 400 to 4 000</td><td>✓</td><td>✓</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Reference document</td><td>IEC 60825-2:2021 Table 4
IEC 60825-1:2014 Table 10</td><td>IEC 60825-1:2014 Table 3</td><td>IEC 60825-1:2014 Table 4</td><td colspan="3">IEC 60825-1:2014 Table 9</td></tr>
</table>

When considering optical transceivers for fibre optic telecommunication systems, three wavelength ranges are of utmost importance. These wavelength ranges are shown in Table 2. In this document, a case study for these three wavelength ranges is provided to simplify laser class calculations.

Table 2 – Wavelength ranges for fibre optic telecommunication systems

Wavelength range nm	Optical modulation format	Fibre
700 to 1 050	Intensity modulation (on-off keying)	Multimode fibre (MMF)
1 200 to 1 400	Intensity modulation (on-off keying) Coherent modulation (phase-shift keying)	Single-mode fibre (SMF)
1 400 to 4 000	Intensity modulation (on-off keying) Coherent modulation (phase-shift keying)	Single-mode fibre (SMF)

4.3 Time base

In IEC 60825-1 and IEC 60825-2, the time base of exposure is one of the principal parameters for laser class calculations, as shown in IEC 60825-1:2014, Table 3 and Table 4. In the case of optical transceivers and transmitters for fibre optic communication systems, the power of on-off-keyed optical signals varies randomly with time but at relatively high speed, whereas the power of phase-shift-keyed signals, which are often used in coherent transmission systems, is quasi-continuous. In this document, a time base of more than 100 s is assumed for Table 3 and Table 4 in IEC 60825-1:2014 to simplify the calculations, considering actual laser product emission duration.

4.4 Hazard for eye and skin

In case of calculating laser safety specifications, the hazards for eye and skin are both considered to satisfy the laser safety conditions.