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TECHNICAL REPORT

colour inside

Safety of laser products – Part 3: Guidance for laser displays and shows

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Safety of laser products –
Part 3: Guidance for laser displays and shows

INTERNATIONAL
ELECTROTECHNICAL
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SAFETY OF LASER PRODUCTS –

Part 3: Guidance for laser displays and shows

FOREWORD

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IEC TR 60825-3 has been prepared by IEC technical committee 76: Optical radiation safety and laser equipment. It is a Technical Report.

This third edition cancels and replaces the second edition published in 2008. This edition constitutes a technical revision.

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

a) updates and provides additional terms and definitions relating to laser displays and shows;
b) adds information on exposure hazards and biological effects;
c) updates and provides additional safety criteria from a technical perspective of equipment and installations;
d) updates and provides additional safety management guidance for designers, installers, operators and performers;
e) adds guidance on identifying and managing laser display risk, including laser effect exposure risk categories to aid management;

f) adds guidance on the management of incidents and accidents;

g) adds guidance on exposure assessment, highlighting evaluation and measurement difficulties, and providing guidance on undertaking measurements.

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

Draft	Report on voting
76/662/DTR	76/692/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.

A list of all parts in the IEC 60825 series, published under the general title *Safety of laser products*, can be found on the IEC website.

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.

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 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

Laser products are used to create visual lighting effects for the purposes of entertainment. IEC 60825-1 considers the hazard classification and engineering requirements of laser products, while IEC TR 60825-14 provides general user guidance for the safe use of laser products.

The laser power needed to produce visually effective theatrical or artistic displays in large spaces such as theatres, arenas, or architectural sites is great enough to pose a severe accidental exposure hazard, even when personal exposure is very brief. For this reason, IEC TR 60825-14 states that only laser products that are Class 1, Class 2 or visible-beam Class 3R should be used for demonstration, display or entertainment purposes in unsupervised areas. Only under carefully controlled conditions and under the control of a trained experienced operator can laser products of higher classes be used for visual entertainment.

This document expands upon the principles considered in IEC TR 60825-14, providing specific technical guidance appropriate for the safe use of laser products used for the purposes of visual entertainment.

SAFETY OF LASER PRODUCTS –

Part 3: Guidance for laser displays and shows

1 Scope

This part of IEC 60825, which is a Technical Report, gives guidance on the planning and design, set-up and conduct of laser displays and shows that make use of high power lasers emitting output between 380 nm and 780 nm.

This document does not include the display or demonstration of scientific, medical or industrial laser products that can be used in an exhibition environment for example. However, several of the principles in this document could be relevant. This document provides recommendations for safety for those laser displays or demonstrations that are shows, artistic displays, advertising or light sculptures, or museum pieces used to demonstrate optical principles, etc.

Laser products available for use in a domestic environment or for use by people who cannot be expected to have received a suitable level of training are typically limited to Class 1, Class 2 or visible-beam Class 3R. Therefore, the use of such equipment is outside the scope of this document.

Image projectors that were assigned a Risk Group in accordance with IEC 62471-5 [1][1] or laser illuminated luminaires employing lamps meeting the criteria of 4.4 of IEC 60825-1:2014, are not within the scope of this document.

This document contains safety criteria for the protection of the public or persons in the vicinity of laser displays in the course of their employment.

This document is intended to be used by those who:

– design, manufacture, assemble, install or operate laser products that are Class 4, Class 3B, or non-visible beam Class 3R for display and entertainment purposes;

– operate arenas, theatres, music festivals, TV studios, planetaria, discotheques or other places where such laser products are installed and operated; or

– are responsible for reviewing the safety of such equipment, installations or displays.

This document is a code of practice for the design, installation, operation and evaluation of the safety of laser light shows and displays, and the equipment employed in their production. This document is also intended for persons who modify laser display installations or equipment.

In some countries, there are specific requirements, such as government permissions or notifications of shows, or prohibitions, such as against laser scanning of spectators.

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1 Numbers in square brackets refer to the Bibliography.

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

3 Terms and definitions

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

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

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

3.1
aversion response
reflex avoidance action (closing the eyes and turning away) when a person is suddenly exposed to a bright light source

Note 1 to entry: Through this action the duration of an accidental exposure to a visible beam is normally considered to be 0,25 s. However, alcohol or narcotic substances can have a detrimental effect on the aversion response, and even without such influences spectators can be inclined to override this response to continue viewing the performance.

3.2
Amsler grid
visual tool used to detect vision problems resulting from damage to the macula, the part of the eye used to detect central vision detail

3.3
ancillary personnel
backstage workers, ushers, security guards, technicians, food and beverage suppliers, etc., who are working at the venue or facility at which a laser display or show is being set up or presented, but who are not directly involved with the laser display or show

Note 1 to entry: Ancillary personnel can have access to areas from which spectators are excluded.

3.4
aperture
opening in the protective housing of a laser product through which laser radiation is emitted, thereby allowing human access to such radiation

Note 1 to entry: The aperture is of limited size so that only the intended laser effect can emit from laser projector.

3.5
audience illumination
laser lighting effect that is intentionally accessible, allowing direct illumination of the area occupied by spectators

Note 1 to entry: Common techniques used to produce this type of effect include:

– direct scanning of the laser beam, using electromechanical devices, such as galvanometers, to deflect the beam position, typically, in a dynamic fashion;

– diffraction effect (3.12) using diffractive optic elements;

– high inertia scanning effects, such as rotating polygon mirror and mirror ball beam deflection;

– solid-state beam deflection techniques, using devices such as acousto-optic modulators and microelectromechanical systems (MEMS).

Note 2 to entry: The varying characteristics associated with each different effect type influence the degree of hazard present and how it can be managed. Factors include differing maximum peak irradiance, exposure duration potential, time available for effective scan-fail detection and mitigation.

3.6
barrier
device to separate spectators from zones where potentially hazardous laser radiation exists

Note 1 to entry: It is important that barriers are robust and not capable of being readily displaced or traversed by spectators.

Note 2 to entry: A barrier can be a wall, a fence, stage front, etc.

Note 3 to entry: Less substantial barriers such as stanchions or ropes can be considered to be adequate barriers if the entire protected area is visible to and monitored by the laser operator or other safety and security personnel during the laser display.

3.7
bounce mirror
mirror located remotely from the laser projector used to target a static beam

Note 1 to entry: Bounce mirrors are often used in multiples to create the appearance of multiple networks of beams.

3.8
control signal
means by which the laser projector is controlled by the laser operator or a pre-programmed control system

Note 1 to entry: The resilience of the control signal to interference from other of sources within the environment is important. For this reason, the use of wireless control signals is discouraged.

3.9
controlled location
area inaccessible except to authorized, trained persons that have received sufficient training or instruction about laser safety

Note 1 to entry: Controlled locations typically include the performer zone, but can also encompass restricted areas where laser beams are accessible. They also include restricted areas in which ancillary personnel can be present or to which ancillary personnel have access.

3.10
designer
person who determines the visual effects to be produced, the planning of the projections, and the locations of the equipment to be used

Note 1 to entry: The designer can, in addition, act as installer or operator and be considered to be a manufacturer (3.27) or supplier.

3.11
display safety record
DSR
written record of safety information relevant to a specific laser display or show

3.12
diffraction effect
type of laser effect produced by the interaction of a laser beam with a diffractive optical element (DOE) or diffraction grating

Note 1 to entry: The laser beam interaction causes the original beam to split and form a geometric pattern, such as a grid or line of beams. The appearance of the emergent pattern is predominantly determined by the characteristics of the DOE. The substrate containing the DOE is usually rotated during use to create the appearance of movement.

Note 2 to entry: Diffraction effects can be produced either by using a reflective substrate which behaves like a mirror, with pattern being formed as a reflection, or by using a transmissive substrate, where the beam passes through the DOE and the pattern is formed at the beam exit. Reflective diffraction effects are often used in similar fashion to bounce mirrors. Transmissive laser effects are typically created within the laser projector itself, with the DOE being moved into the path of a stationary laser beam or scanning output.

Note 3 to entry: Diffraction effects normally contain a zero order (3.46) beam.

3.13
effective pulse duration
time taken for a moving beam to traverse the 7 mm limiting aperture of the eye

Note 1 to entry: Often used for evaluating the exposure created by a scan pattern or moving effect, where in most instances the exposure experienced by a person is independent of the, often CW, laser source output characteristics.

Note 2 to entry: This duration can be estimated by considering the leading and trailing edges of a top-hat scanning beam profile passing over the pupil.

3.14
emergency stop control
e-stop
reliable method of terminating the output of a laser projector system

Note 1 to entry: It is important the emergency stop control functions independently of the laser system's control signal, which can become unstable in the case of a fault occurring. This is particularly important as common lighting and laser effect control protocols generally have no or little fault tolerance.

3.15
engineering control
mechanical or electrical safety measure intended to continuously protect people from exposure to a hazard, usually characterized by being in addition to the system and not relying on specific human action to be effective

Note 1 to entry: Common examples include key operated controls, warning indicators, and physical masking.

3.16
errant laser effect
laser beam that deviates from a defined or intended beam path

Note 1 to entry: Such beams include unwanted reflections in the projection area, or movement of the laser projector or remote optical target causing laser beams to appear outside of the intended projection area.

3.17
inaccessible location
area that can be accessed only using specialized equipment, additional equipment, or both

Note 1 to entry: Access equipment typically includes mobile lifts, ladders, ropes, scaffolding, etc.

3.18
intentionally accessible effect
laser effect category that by design and implementation permits beams to be readily accessible to persons

Note 1 to entry: An example of this category of effect is audience illumination, but could equally apply to others, such as performers and ancillary personnel illumination. In each instance it is important that any exposure is not in excess of the applicable MPE.

3.19
installer
person who places the equipment in the designated locations and participates in the adjustment and alignment to produce the desired effects

Note 1 to entry: An installer may also be a manufacturer (3.27) or supplier if the installation activities result in modification of the display laser product effects.

3.20
laser classification
indication of the potential risk of harm of a laser, where the higher the class number indicates a greater hazard from exposure to the laser beam emitted by the product

Note 1 to entry: IEC 60825-1 defines eight distinct laser hazard classes that identify the general risk posed by a laser product and mandates the required safety features that the laser product is to have based on its accessible laser radiation.

Note 2 to entry: The majority of laser projectors used to create laser effects are Class 3B and Class 4 laser products that emit beam(s) posing a risk to eyes and skin, and can act as a source of fire ignition.

3.21
laser display or show
activity where at least one laser beam is projected onto a surface or made visible in the air, for purposes such as entertainment or art, and usually intended to be viewed by a non-specialist audience

Note 1 to entry: This definition includes demonstrations, such as in museums or educational establishments, and laser shows such as in planetariums, nightclubs, concert and entertainment venues, art installations and advertising projections.

3.22
laser effect
all electromagnetic radiation emitted by a laser product between 380 nm and 780 nm which is produced as a result of controlled stimulated emission

Note 1 to entry: A laser effect can appear stationary or moving using optical components to manipulate the characteristics of the laser beam.

3.23
laser effect category
identification of the laser effect application based on the intended accessibility to the laser beam(s)

Note 1 to entry: Laser effects are considered to belong to one of three categories based on the potential for direct exposure, which helps to identify the specific types of controls necessary to safely manage use of the laser effect.

3.24
laser projector
laser used, alone or with beam-manipulating components, to produce laser displays or show effects

Note 1 to entry: Laser projectors are considered laser products subject to the applicable provisions of IEC 60825-1, within the scope of this document.