TEST REPORT
IEC 60825-1
Safety of laser products -
Part 1: Equipment classification and requirements

Report Number. ..... :	**SHES230801506971**
Date of issue ..... :	2023-08-15
Total number of pages ..... :	15 Pages
Name of Testing Laboratory preparing the Report ..... :	SGS-CSTC Standards Technical Services (Shanghai) Co., Ltd.
Applicant's name ..... :	Hangzhou LuminWave Technology Co.,Ltd.
Address ..... :	Room 1203, Room 1203, Building B, 459 Jianghong Road, Binjiang District, Hangzhou, Zhejiang, CHINA, 310000
Test specification:	
Standard ..... :	IEC 60825-1:2014
Test procedure ..... :	SGS-CSTC
Non-standard test method ..... :	N/A
TRF template used ..... :	IECEE OD-2020-F1:2021, Ed.1.4
Test Report Form No. ..... :	IEC60825_1G
Test Report Form(s) Originator .... :	OVE
Master TRF ..... :	Dated 2021-10-05

This report is not valid as a CB Test Report unless signed by an approved IECEE Testing Laboratory and appended to a CB Test Certificate issued by an NCB in accordance with IECEE 02.

General disclaimer:

The test results presented in this report relate only to the object tested.
This report shall not be reproduced, except in full, without the written approval of the Issuing NCB. The authenticity of this Test Report and its contents can be verified by contacting the NCB, responsible for this Test Report.

Test item description ..... :	D series TOF Camera
Trade Mark(s) ..... :	LuminWave
Manufacturer ..... :	Same as applicant
Model/Type reference ..... :	LWP-D3ABC
Ratings ..... :	12VDC; 3,5A

Responsible Testing Laboratory (as applicable), testing procedure and testing location(s):

☒	**Testing Laboratory:**	SGS-CSTC Standards Technical Services (Shanghai) Co., Ltd.	
Testing location/ address.....:		588 West Jindu Road, Xinqiao, Songjiang, Shanghai, China.	
Tested by (name, function, signature).....:		Abby Yang PE	
Approved by (name, function, signature)...:		Emilien Li Reviewer	
☐	**Testing procedure: CTF Stage 1:**		
Testing location/ address.....:			
Tested by (name, function, signature).....:			
Approved by (name, function, signature)...:			
☐	**Testing procedure: CTF Stage 2:**		
Testing location/ address.....:			
Tested by (name + signature).....:			
Witnessed by (name, function, signature) .:			
Approved by (name, function, signature)...:			
☐	**Testing procedure: CTF Stage 3:**		
☐	**Testing procedure: CTF Stage 4:**		
Testing location/ address.....:			
Tested by (name, function, signature).....:			
Witnessed by (name, function, signature) .:			
Approved by (name, function, signature)...:			
Supervised by (name, function, signature) :			

List of Attachments (including a total number of pages in each attachment):

Attachment 1 – 16 pages of European group differences and national differences

Summary of testing:

Normal operation and reasonably foreseeable single fault were both considered.
The test results comply with the requirements of Class 1 laser product.

Tests performed	**Testing location:**
Clause 4 Classification principles Clause 5 Determination of the accessible emission level and product classification	SGS-CSTC Standards Technical Services (Shanghai) Co., Ltd. 588 West Jindu Road, Xinqiao, Songjiang, 201612 Shanghai, China.

Summary of compliance with National Differences (List of countries addressed):

List of countries addressed

1. EU Group Differences (EN 60825-1: 2014+A11: 2021)
2. EU Special National Conditions, EU A-deviations: DE, DK, FI, GB, IE, NO, SE

   Explanation of used codes: DE=Germany, DK=Denmark, FI=Finland, GB= United Kingdom, IE=Ireland, NO=Norway, SE=Sweden

☒ **The product fulfils the above requirements.**

Use of uncertainty of measurement for decisions on conformity (decision rule) :

☒ No decision rule is specified by the IEC standard, when comparing the measurement result with the applicable limit according to the specification in that standard. The decisions on conformity are made without applying the measurement uncertainty ("simple acceptance" decision rule, previously known as "accuracy method").

☐ Other:… (to be specified, for example when required by the standard or client, or if national accreditation requirements apply)

Information on uncertainty of measurement:

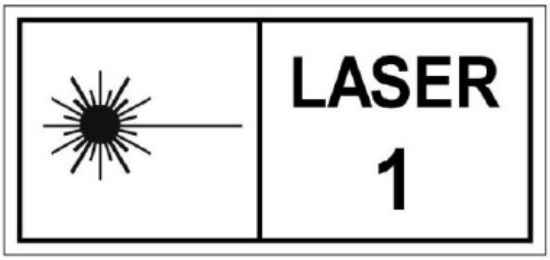
The uncertainties of measurement are calculated by the laboratory based on application of criteria given by OD-5014 for test equipment and application of test methods, decision sheets and operational procedures of IECEE.

IEC Guide 115 provides guidance on the application of measurement uncertainty principles and applying the decision rule when reporting test results within IECEE scheme, noting that the reporting of the measurement uncertainty for measurements is not necessary unless required by the test standard or customer.

Calculations leading to the reported values are on file with the NCB and testing laboratory that conducted the testing.

Copy of marking plate:

The artwork below may be only a draft. The use of certification marks on a product must be authorized by the respective NCBs that own these marks.



IEC 60825-1: 2014

EN 60825-1: 2014+A11: 2021

Test item particulars.....:	--
Classification of installation and use.....:	--
Supply Connection.....:	--
.....:	--
Possible test case verdicts:	
- test case does not apply to the test object.....:	N/A
- test object does meet the requirement.....:	P (Pass)
- test object does not meet the requirement.....:	F (Fail)
Testing.....:	
Date of receipt of test item .....:	2023-08-03
Date (s) of performance of tests.....:	2023-08-03 to 2023-08-11

General remarks:

"(See Enclosure #)" refers to additional information appended to the report.
"(See appended table)" refers to a table appended to the report.

Throughout this report a ☒ comma / ☐ point is used as the decimal separator.

☐ **This Test Report Form contains requirements according to IEC/ISO …... Standard dated ….. and includes** Corrigendum dated …….
(Note: The above text maybe removed if not applicable)

Manufacturer's Declaration per sub-clause 4.2.5 of IECEE 02:

The application for obtaining a CB Test Certificate includes more than one factory location and a declaration from the Manufacturer stating that the sample(s) submitted for evaluation is (are) representative of the products from each factory has been provided ..... :	☐ **Yes** ☒ **Not applicable**

When differences exist; they shall be identified in the General product information section.

Name and address of factory (ies) ..... : Same as applicant

General product information and other remarks:

The product is a TOF Camera with 2 laser light source.

Laser source specification:

Manufacturer/Trademark	Model reference	Characteristic/Spec
Vertilite	P35940S2K005	940nm; 3,5A; 4,8 V

Reasonably foreseeable single fault was considered by the client that it is impossible to emit a laser exceeds the normal operating mode nor become CW.

The product is classified to a **Class 1** laser product for both above conditions.

Following information should be on the manual:
a) adequate instructions for assembly, maintenance and safe use and description of the classification limitations, if appropriate.
b) additional warning for Class 1M and 2M
c) laser beam parameters for radiation above the AEL of Class 1 (Wavelength; Beam divergence; Maximum power or energy output)
d) safety instruction for embedded laser products and other incorporated laser products.
e) MPE and NOHD for Class 3B and 4 laser products; For collimated beam Class 1M and 2M lasers the extended NOHD (ENOHD).
f) information for the selection of eye protection.
g) reproduction of all required labels and warnings.
h) location of laser apertures
i) list of controls, adjustments of procedures for operation and maintenance - and warning statement.
j) information (compatibility requirements) about laser energy source if not incorporated.
k) additional warning for Class 1, 1M, 2, 2M, and 3R regarding skin or corneal burns.

IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict

4	**CLASSIFICATION PRINCIPLES**		
4.3	Classification rules		---
4.3 a	Radiation of a single wavelength		P
4.3 b	Radiation of multiple wavelengths		N/A
	1) Laser product emits at two or more wavelengths shown as additive in Table 1		N/A
	2) Laser product emits at two or more wavelengths not shown as additive in Table 1		N/A
4.3 c	Radiation from extended sources (see 5.4.3)		N/A
4.3 d	Non-uniform, non-circular or multiple apparent source		P
4.3 e	Time bases		---
	1) 0,25 s		N/A
	2) 100 s	Class 1	P
	3) 30000 s		N/A
4.3 f	Repetitively pulsed or modulated lasers		P
	1) Any single pulse		P
	2) Average power for pulse trains		P
	3) Pulse duration $t \leq T_i$ .....: Number of pulses N and C_5 .....:		N/A
	3) Pulse duration $t > T_i$ .....: Number of pulses N and C_5 .....:	See page 9	P
4.4	Laser products designed to function as conventional lamps.		N/A
	α measured at 200 mm distance from closest point of human access ($\alpha > 5$ mrad).		N/A
	Un-weighted radiance L measured at 200 mm distance (comparison with $L_T = 1\ MWm^{-2}sr^{-1}$/) under reasonably foreseeable single fault conditions.		N/A
	Evaluation of emission according to IEC 62471 series (optional): Standard applied (IEC 62471 series)……,….. ....: Risk Group…….…….. ....: Labelling……....: Classification of product based on accessible laser radiation (if no laser radiation accessible: Class 1).		N/A

IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict

5	**DETERMINATION OF THE ACCESSIBLE EMISSION LEVEL and PRODUCT CLASSIFICATION**		
5.1	Tests		---
	Compliance under reasonably foreseeable single fault conditions.	Single fault was considered by the client that it is impossible to emit a laser exceeds the normal operating mode nor become CW.	P
5.3	Determination of the class of the laser product ...: For Class 1C: vertical safety standard applied with requirements for Class 1C.		---
5.4	Measurement geometry		---
5.4.1	General		---
5.4.2	Default (simplified) evaluation		N/A
	Conditions applied .....:		N/A
	Aperture diameter .....:		N/A
	Reference point :.....:		N/A
	Measurement distance .....: (for each condition)		N/A
5.4.3	Evaluation condition for extended sources		P
	Conditions applied .....:	Condition 3	P
	Most restrictive position .....: (distance from reference point)	100 mm	P
	Angular subtense of the apparent source α and C_6: (for each condition)	See page 9	P
5.4.3 a	Aperture diameters (for each condition).....:	7	P
5.4.3 b	Angle of acceptance (for each condition)……...:	Not limited	P

IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict

Measured accessible laser radiation and comparison with AEL:

The measured peak wavelength is 940,5 nm.

Compared with condition 1, test result under condition 3 is stricter. Test performed on condition 3.

The product is a three nested pulsed laser:

T_{st}	104 ms
Duty cycle$_{st}$	40,6%
T_{nd}	5,9 ms
Duty cycle$_{st}$	44,4%
T_{rd}	50ns
Duty cycle$_{rd}$	50%
$t_{train\ 1}$	42,2 ms
$t_{train\ 2}$	2,6 ms
Single pulse duration	25 ns
Average duty cycle	9%

AELs for Class 1:

α=54 mrad; α_{max_single}=5 mrad; C_{6_single}=3,333; α_{max_T}=100 mrad; C_{6_T}=36; C_4=3,027; T_2=34,119; Ti=5*10^{-6}; N_{train1}=328; N_{train2}=2347; C_5=0,4; C_{6_train1}=27,398; C_{6_train2}=6,824

AEL_{single} = 7,7*10^{-8} C_4C_6 J = 7,769*10^{-7} J

AEL_T =7*10^{-4} $C_4C_6T_2^{-0.25}$ W = 3,156*10^{-2} W

$AEL_{s.p.train1}$= AEL_{single_train1}*C_5=7*10^{-4} $t^{0.75}C_4C_6C_5$J = 2,163*10^{-3} J

$AEL_{s.p.train2}$= AEL_{single_train2}*C_5=7*10^{-4} $t^{0.75}C_4C_6C_5$J = 6,697*10^{-5} J

Considered at 0 mm at 3,5mm diameter aperture: 500mW (AEL for class 3B)

Measurement:

Average power=1,724*10^{-3} W; single pulse power=1,916*10^{-2} W

Exposure from single pulse =1,916*10^{-2}*2,5*10^{-8} J=4,789*10^{-10} J < AEL_{single}

Average power for a pulse train = 1,724*10^{-3} W < AEL_T

Energy per pulse $_{train1}$ =3,591*10^{-4}J

Energy per pulse $_{train2}$ =2,509*10^{-5}J

Accessible emission for 3,5mm aperture at 0 mm = 47,6 mW < 500mW

Test data doesn't exceed the limits of Class 1.

Therefore, the product has been classified to **Class 1 laser product**.

IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict

6	**ENGINEERING SPECIFICATIONS**		**P**
6.2	Protective housing		---
6.2.1	General		---
	Protective housing prevents access to energy levels in excess of the AEL for Class 1.	Class 1 Product.	P
	Protective housing prevents access to energy levels equivalent to Class 4 and withstands exposures under reasonably foreseeable single fault conditions.		N/A
	Maintenance of Class 1, 1C, 1M, 2, 2M, or 3R (access to emissions of Class 3B or 4 is prevented).		N/A
	Maintenance of Class 3B product (access to emission of Class 4 is prevented).		N/A
6.2.2	Service		N/A
6.2.3	Removable laser system (laser system complies with requirements of Clauses 6 and 7).		N/A
6.3	Access panels and safety interlocks		---
6.3.1	Panel is intended to be removed during operation (or maintenance) and would give access to higher energy levels (see Table 13).		N/A
	Accessible emission (after removal of the panel) corresponds to product Class (designated by “X” in Table 13)		N/A
	Emission through the opening if interlocked panel of Class 1, 1C, 1M, 2, or 2M is removed (Emission < AEL of Class 1M or 2M).		N/A
	Emission through the opening if interlocked panel of Class 3R, 3B, or 4 is removed (Emission < AEL of Class 3R).		N/A
	Requirements regarding reasonably foreseeable single fault condition.		N/A
6.3.2	Override mechanism		N/A
	Behaviour of override in operation when the panel is replaced.		N/A
	Visible or audible warning for override mode.		N/A
6.4	Remote interlock connector		N/A
6.5	Manual reset		N/A
6.6	Key control		N/A
6.7	Laser radiation emission warning		---

IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict
6.7.1	Laser product is a 3R (λ<400 nm; λ>700 nm), 1C, 3B or 4 laser systems.		N/A
6.7.2	Audible or visible warning.		N/A
	Warning is failsafe or redundant.		N/A
	Viewing of the visible warning does not require exposure to emissions > AEL for Class 1M and 2M.		N/A
6.7.3	Operational control and laser aperture are provided with a warning device when they are separated more than 2 m from warning device.		N/A
6.7.4	Visible indication of output aperture if laser emission may be distributed through more than one output.		N/A
6.7.5	Switch for handheld Class 3R device must be depressed for emission (in lieu of emission indicator).		N/A
6.8	Beam stop or attenuator		N/A
6.9	Controls		N/A
6.10	Viewing optics		N/A
	a) Human access to laser radiation in excess of Class 1M prevented when the shutter is opened or attenuation varied.		N/A
	b) Opening of the shutter or variation of the attenuation prevented when exposure to laser radiation in excess of Class 1M is possible.		N/A
6.11	Scanning safeguard		N/A
6.12	Safeguard for Class 1C products		N/A
	a) Human access to laser radiation in excess of AEL for Class 1 measured under Condition 3 is prevented.		N/A
	b) Human access to laser radiation in excess of AEL for Class 3B measured through 3,5 mm aperture at 5 mm distance from applicator is prevented.		N/A
6.13	Walk-in access		
	a) Means provided so that any person inside the housing can prevent activation of Class 3B or 4 laser hazards.		N/A
	b) A warning device provides adequate warning of emission to any person within the housing.		N/A
	c) Where “walk-in” access during operation is intended or reasonably foreseeable, emission of laser radiation that is equivalent to Class 3B or 4 while someone is present inside the enclosure of Class 1, Class 2 or Class 3R product is prevented by engineering means.		N/A

IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict
6.14	Environmental conditions		---
	- climatic conditions	Not considered in this report	N/A
	- vibration and shock		N/A
6.15	Protection against other hazards		---
6.15.1	Non-optical hazards (product safety standard)	Not considered in this report	N/A
	- electrical hazards;		N/A
	- excessive temperature;		N/A
	- spread of fire from the equipment;		N/A
	- sound and ultrasonics;		N/A
	- harmful substances;		N/A
	- explosion;		N/A
6.15.2	Collateral radiation	Not considered in this report	N/A
6.16	Power limiting circuit		P

7	**LABELLING**		
7.1	General		---
	Labels durable, permanently affixed		P
	Labels clearly visible		P
	Reading of labels is possible without exposure to laser radiation in excess of AEL for Class 1.		P
	Colour combination		N/A
	Labelling impractical due to the size or design of the product.		P
	Warning label – Hazard symbol (Figure 3)		P
7.2 - 7.7	Text on explanatory label or pictogram (laser class, warning text)		P
7.8	Aperture label		N/A
7.9	Radiation output and standards information		---
	Max output of laser radiation .....:		N/A
	Pulse duration .....:		N/A
	Emitted wavelength(s) .....:		N/A
	Name and publication date of the standard .....:		P
7.10	Labels for access panels		---
7.10.1 a) – f)	Labels for panels - warning wording used .....:		N/A

IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict
7.10.2	Labels for safety interlocked panels - Warning wording used .....:		N/A
7.11	Warning for invisible laser radiation .....:	See Label	P
7.12	Warning for visible laser radiation .....:		N/A
7.13	Warning for potential hazard to the skin or anterior parts of the eye - warning wording used .....:	Laser power do not exceed AEL for Class 3B with a 3,5 mm diameter aperture placed at the closest point of human access	N/A
8	**OTHER INFORMATIONAL REQUIREMENTS**		
8.1	Information for the user		---
	a) adequate instructions for assembly, maintenance and safe use and description of the classification limitations, if appropriate.		P
	b) additional warning for Class 1M and 2M		N/A
	c) laser beam parameters for radiation above the AEL of Class 1	Class 1	
	• Wavelength .....:		N/A
	• Beam divergence .....:		N/A
	• Pulse pattern .....: (pulse duration, repetition rate, …)		N/A
	• Maximum power or energy output .....:		N/A
	d) safety instruction for embedded laser products and other incorporated laser products.		P
	e) MPE and NOHD for Class 3B and 4 laser products; For collimated beam Class 1M and 2M lasers the extended NOHD (ENOHD).		N/A
	f) information for the selection of eye protection.		P
	g) reproduction of all required labels and warnings.		P
	h) location of laser apertures	Class 1	N/A
	i) list of controls, adjustments of procedures for operation and maintenance - and warning statement.		P
	j) information (compatibility requirements) about laser energy source if not incorporated.		N/A
	k) additional warning for Class 1, 1M, 2, 2M, and 3R regarding skin or corneal burns.		N/A
	l) Information for Class 1C products (e.g. warning that repeated application may pose a risk).		N/A

IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict
8.2	Purchasing and service information		P
	a) safety classification of each laser product stated in all descriptive material (e.g. brochures).		P
	b) adequate instructions for servicing available: • warnings and precautions regarding exposure of laser emission above Class 1 • maintenance schedule • list of controls and procedures that could increase accessible emissions • description of displaceable parts • protective procedures for service personnel • reproduction of labels and hazard warnings		P
9	**ADDITIONAL REQUIREMENTS FOR SPECIFIC LASER PRODUCTS**		
9.1	Applicable other parts of the standard series IEC 60825		---
	IEC 60825-2 (Safety of optical communication systems)		N/A
	IEC 60825-4 (Laser guards)		N/A
	IEC 60825-12 (Safety of free space optical communication systems used for transmission of information)		N/A
9.2	Medical laser products: Class 3B and Class 4 medical laser products comply with IEC 60601-2-22		N/A
9.3	Laser processing machines: Comply with IEC/ISO 11553 series.		N/A
9.4	Electric toys: Comply with IEC 62115		N/A
9.5	Consumer electronic products: Comply with IEC 60950 (IT-equipment) or IEC 60065 (AV equipment)		N/A

IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict

Annex 1: Photo documentation

Type of equipment, model: See main report

Details of: overview

View:

[X] general

[ ] front

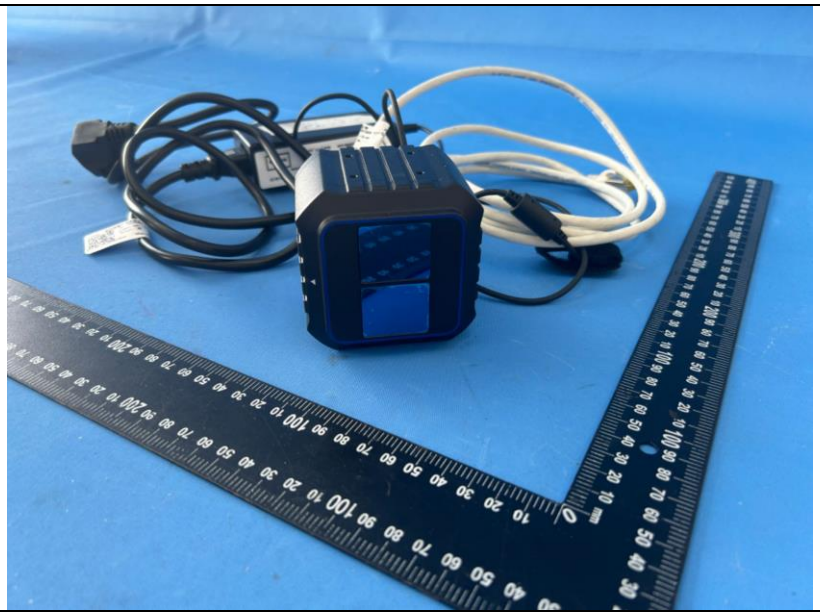
[ ] rear

[ ] right

[ ] left

[ ] top

[ ] bottom



Details of: overview

View:

[X] general

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---End of Report---

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
ATTACHMENT TO TEST REPORT **IEC 60825-1** **EUROPEAN GROUP DIFFERENCES AND NATIONAL DIFFERENCES** (**Safety of laser products - Part 1: Equipment classification and requirements**)			
Differences according to .....: EN 60825-1:2014+A11:2021			
TRF template used..... : IECEE OD-2020-F2:2020, Ed. 1.1			
Attachment Form No. .....: EU_GD_IEC60825_1G **Attachment Originator**.....: TÜV Rheinland LGA Products GmbH **Master Attachment** .....: Dated 2021-11-05			
Copyright © 2021 IEC System for Conformity Testing and Certification of Electrical Equipment (IECEE), Geneva, Switzerland. All rights reserved.			
	CENELEC COMMON MODIFICATIONS (EN)		--
1	**Scope and object**		P
	In Clause 1, replace the existing text: "This Part 1 describes the minimum requirements. Compliance with this Part 1 may not be sufficient to achieve the required level of product safety. Laser products may also be required to conform to the applicable performance and testing requirements of other applicable product safety standards. NOTE 3 Other standards may contain additional requirements. For example, a Class 3B or Class 4 laser product may not be suitable for use as a consumer product." Where a laser system forms a part of equipment which is subject to another IEC product safety standard, e.g. for medical equipment (IEC 60601-2-22), IT equipment (IEC 60950 series), audio and video equipment (IEC 60065), audio-video and IT equipment (IEC 62368-1), equipment for use in hazardous atmospheres (IEC 60079), or electric toys (IEC 62115), this Part 1 will apply in accordance with the provisions of IEC Guide 1042 for hazards resulting from laser radiation. If no product safety standard is applicable, then IEC 61010-1 may be applied." *with the following:*		P

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
	"This Part 1 describes requirements that are considered sufficient to achieve the required level of product safety for general laser products with respect to hazards to the eye and skin posed by laser radiation, provided that consumer laser products comply with EN 506891 (see 9.5 in EN 60825-1:2014/FprAA:2020). Also, as required in 5.3 b) of EN 60825-1, that laser products classified as Class 1C comply with the respective applicable part of either the EN 60601 series or the EN 60335 series that contains requirements for the safe exposure of the skin (note that the exposure of the skin is not necessarily limited to the MPE values of the skin), if applicable, as well as specific requirements for the performance and testing of the safeguard that prevents hazardous emission towards the eye. Depending on the type of the product, laser products such as for example medical lasers, machines or toys can be required to conform to the applicable performance and testing requirements of their relevant product safety standards. NOTE 3 See 3.92 for "general laser product". Where a laser system forms a part of equipment which is subject to another IEC product safety standard, e.g. for medical equipment (IEC 60601-2-22), IT equipment (IEC 60950 series), audio and video equipment (IEC 60065), audio-video and IT equipment (IEC 62368-1), electrical equipment for measurement, control, and laboratory use (IEC 61010-1), equipment for use in hazardous atmospheres (IEC 60079), or electric toys (IEC 62115), this Part 1 will apply in accordance with the provisions of IEC Guide 1042 for hazards resulting from laser radiation."		
3	**Terms and definitions** *In Clause 3, add the following terms and their definitions:*		P
3.9.1	**consumer laser product** any product or assembly of components that: (a) is intended for consumers, or likely to be used by consumers under reasonably foreseeable conditions even if not intended for them; and (b) constitutes or incorporates a laser or laser system		N/A
3.9.2	**general laser product** laser product that does not fall within the scope of another EN standard that addresses the safety of a specific category of laser products Note 1 to entry: Examples of products where such other EN Standards exist are medical lasers (EN 60601-2-22), electric toys (EN 62115) or laser processing machines (EN ISO 11553-1, EN ISO 11553-2). Note 2 to entry: General laser products are for instance laboratory equipment, laser products for measurements, laser pointers, display lasers and laser illuminated projectors. Note 3 to entry: EN 506891 is not considered as another EN standard that addresses the safety of a specific category of laser products, since it applies to all consumer laser products."		P

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
4.3	**Classification rules** *In Note 3 of 4.3 c), replace the following text:* "NOTE 3 A source is considered an extended source when the angular subtense of the source is greater than αmin, where αmin = 1,5 mrad. Most laser sources have an angular subtense α less than αmin, and appear as an apparent "point source" (small source) when viewed from within the beam (intra-beam viewing). Indeed a circular laser beam cannot be collimated to a divergence less than 1,5 mrad if it is an extended source, thus any laser where a beam divergence of 1,5 mrad or less is specified cannot be treated as an extended source. For a small source, α is set to αmin = 1,5 mrad and *C*6 = 1." *with:* "NOTE 3 An apparent source is considered an extended source when the angular subtense of the apparent source (i.e. the angular subtense of the image of the source) is greater than αmin, where αmin = 1,5 mrad (note that different accommodation states as well as different positions in the beam have to be considered for the classification of extended sources). Most laser sources have an angular subtense α less than αmin, and appear as an apparent "point source" (small source) when viewed from within the beam (intra-beam viewing). Indeed, if a laser beam is to qualify as an extended source, it cannot be collimated to a divergence less than 1,5 mrad unless it is astigmatic (i.e. could be collimated in one dimension only) or scanning. Thus any non-scanning circularly symmetric laser beam, where a beam divergence of 1,5 mrad or less is specified, cannot be treated as an extended source, since accommodation to infinity for intrabeam viewing of such a source produces a retinal image that subtends an angle of less than 1,5 mrad. Also, more generally, any circular, non-scanning high quality Gaussian beam (TEM00) with a beam quality factor M2 equal or close to unity is associated to a small apparent source, as either the beam waist subtends an angular subtense smaller than 1,5 mrad or the divergence is smaller than 1,5 mrad. For a small source, α is set to αmin = 1,5 mrad and *C*6 = 1. See also definitions 3.7, 3.10, 3.36, 3.42. A frequent mistake is to associate the beam diameter, or the beam profile, at the laser aperture with the apparent source; the laser aperture as such has no special distinctiveness that is related to the apparent source. Examples of designs that might constitute an extended source are: transmissions through a diffusor, transmissions through a diffractive optical element (DOE), partially coherent beams (i.e. beams with low beam quality and therefore higher values of the beam quality factor M2), scanned emission, fibres, and astigmatic beams (since the eye cannot accommodate to both waists at the same time). Measurements of the image of the apparent source are expected to be performed with sufficient accuracy, typically with a laser beam profiler CCD camera. As an alternative to characterizing the angular subtense of the apparent source (note that different accommodation states are expected to be considered, as well as different positions in the beam, see 5.4.3), *C*6 can be set to unity (simplified evaluation, see 5.4.2)."		P

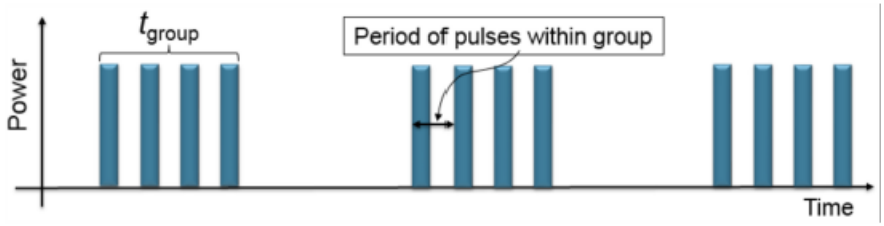
IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
5.3	**Determination of the class of the laser product** *In subclause 5.3, replace the existing text of footnote d of Table 3, footnote f of Table 4, footnote d of Table 6 and footnote c of Table 7:* "In the wavelength range between 1 250 nm and 1 400 nm, the upper value of the AEL is limited to the AEL value for Class 3B." *with:* "In the wavelength range between 1 250 nm and 1 400 nm, two additional limitations apply. The value of the AEL in the table above is limited to the AEL value for Class 3B. The accessible emission, determined with the specified aperture stop, is limited by the following values (these limits are derived from the MPE of the skin and are required as an additional limit to protect the anterior parts of the eye). This limitation for the eye is to be treated as additive with the spectral region of 1400 nm to 10^6 nm listed in Table 1. For $t < 10^{-9}$ s: $7{,}9 \times 10^5$ W — Aperture stop diameter: 1 mm For 10^{-9} s ≤ $t < 10^{-7}$ s: $7{,}9 \times 10^{-4}$ J — Aperture stop diameter: 1 mm For 10^{-7} s ≤ t < 0,35 s: $4{,}3 \times 10^{-2}\ t^{0{,}25}$ J — Aperture stop diameter: 1 mm For t ≥ 0,35 s: 0,1 W — Aperture stop diameter: 0,35 s ≤ t < 10 s: $1{,}5\ t^{3/8}$ mm t ≥ 10 s: 3,5 mm		N/A

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
6.2.1	**General** *In 6.2.1, replace the existing first paragraph:* "Each laser product shall have a protective housing which, when in place, prevents human access to laser radiation (including errant laser radiation) in excess of the AEL for Class 1, except when human access is necessary for the performance of the function(s) of the product." *with:* "Each laser product shall have a protective housing which, when in place, prevents human access to laser radiation (including errant laser radiation) in excess of the AEL for Class 1, unless human access to laser radiation is necessary for the performance of the function(s) of the product. Where human access to radiation levels above the AEL for Class 1 is necessary, the product shall be in the lowest feasible class commensurate with this function. NOTE Where such human access is necessary only at certain times and not during routine operation of the product (e.g. to allow specific maintenance procedures, which are described in the information for the user, to be undertaken by the user) the protective housing prevents human access to laser radiation in excess of the AEL for Class 1 during routine operation. This requirement for a protective housing does not mean that the product needs to meet all the requirements for, and to be classified as, Class 1. This is because classification as Class 1 cannot be achieved when access to levels of laser radiation of Class 3B or Class 4 is necessary during maintenance procedures."		P

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
9.5	**Consumer electronic products** *Replace the entire text of subclause 9.5 with the following:* "Consumer laser products shall comply with applicable requirements for laser products of their class as well as with EN 506891. In addition, these products may be subject to specific safety standards such as EN 62368-1 (AV/ICT equipment). Products that are classified as Class 1C need to comply with the requirements of the respective specific vertical standard of the EN 60335 series or the EN 60601 series. NOTE EN 506891 will be made available after the publication of EN 60825-1:2014/FprAA:2020. In the period of time until EN 506891 is published, there are no specific requirements for consumer products. It is noted that some EU member states have issued guidance documents and/or legal requirements that apply to consumer laser products and that are not harmonized amongst EU member states."		N/A
ZB	**ANNEX ZB**		P
ZB.1	**General remarks** This informative annex is added to EN 60825-1:2014 in order to publish the content of the IEC Interpretation Sheets IEC 60825-1:2014/ISH1:2017 and IEC 60825-1:2014/ISH2:2017 by CENELEC. The content is published as an annex to EN 60825-1, because the publication type "Interpretation Sheet" is not available at CENELEC level. Because there are no page-number limitations for an annex (contrary to an Interpretation Sheet), the text of the IEC ISH1 and ISH 2 has been somewhat extended in order to increase the readability and clarity.		P
ZB.2	**Subclause 4.3 Classification rules (IEC 60825-1:2014/ISH1:2017)**		P
ZB.2.1	**General remarks** This subclause ZB.2 contains the text of ISH1; some examples were added for clarity. For some complex extended sources or irregular temporal emissions, the application of the rules of 4.3 may require clarification. In this subclause ZB.2, 4.3 (Classification rules) is clarified. NOTE 1 For the purpose of this annex, the abbreviation "AE" is used for "accessible emission". NOTE 2 The clarifications also apply in an equivalent way to MPE analysis, i.e. for Annex A.		P

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
ZB.2.2	**Subclause 4.3 c) (Radiation from extended sources)** When using the default (simplified) evaluation method (5.4.2) for wavelengths ≥ 400 nm and < 1 400 nm, the angle of acceptance may be limited to 100 mrad for determining the accessible emission to be compared against the accessible emission limit, except in the wavelength range 400 nm – 600 nm for durations longer than 100 s where the circular-cone angle of acceptance is not limited. When evaluating the emissions for comparison to the Class 3B AELs, the angle of acceptance is not limited.		N/A
ZB.2.3	**Subclause 4.3 d) (Non-uniform, non-circular or multiple apparent sources)** In 4.3 d), for comparison with the thermal retinal limits, the requirement to vary the angle of acceptance in each dimension might appear to contradict the labelling in Figure 1 and Figure 2 of 5.4.3 where the field stop is labelled as circular.		P

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
ZB.2.4	**Subclause 4.3 f) 3); determination of α** The parameter αmax is a function of emission duration, i.e. αmax(*t*). For an analysis of pulsed emission and extended sources, αmax(*t*) limits both the value of α for the determination of *C*6(α) as well as the angle of acceptance γ for the determination of the accessible emission (see 4.3 c) and d) and subclause ZB.2.3 of this amendment). In this process, αmax(*t*) is determined for the same emission duration *t* that is used to determine AEL(*t*) (i.e. the pulse duration or the pulse group duration for 4.3 f) 3) and the averaging duration for 4.3 f) 2), respectively). However, the parameter α is also used in 4.3 f) 3) in the criteria to determine which *C*5 is applied to AELs.p.train(*t*). For these criteria to determine *C*5, the parameter α is not limited to αmax(*t*) in the same way as for the determination of *C*6 according to 4.3 d). To determine *T*2(α) and in the criteria of 4.3 f) 3) “For α ≤ 5 mrad”, “For 5 mrad < α ≤ αmax”, and, “For α > αmax”, the quantity α is equal to the “long-term” α, i.e. equal to α as determined for a time base of 0,25 s or equal to the value of α of *T*2(α). In the determination of this “long-term” α (applying the method specified in 4.3 d)), αmax = 100 mrad. That is, for *T*2 and these inequalities, α is not limited to a value of αmax(*t*) smaller than 100 mrad, and is therefore the same as the value that applies for the determination of *C*6 for the time base of 0,25 s or 100 s, as applicable. As is generally defined (see 4.3 d)) the arithmetic mean is applied to determine α, i.e. it is not necessary that both dimensions satisfy the criterion ”For α ≤ 5 mrad” independently. For the criterion “Unless α > 100 mrad”, the angular subtense of the apparent source α is not restricted by αmax. For non-uniform (oblong, rectangular, or linear) sources, the inequality needs to be satisfied by both angular dimensions of the source in order for *C*5 = 1 to apply. The value of α determined with αmax = 100 mrad (i.e. the “long-term” α) can also be used for this criterion, alternatively: in this case the criterion is written as “Unless α = 100 mrad”, because for α to become exactly equal to 100 mrad, when applying αmax = 100 mrad, the image of the apparent source has to be larger than 100 mrad in both dimensions. Since the “long-term” α is needed for the inequalities in 4.3 f) 3) to determine the applicable *C*5, the usual sequence is as follows. An analysis of the image of the apparent source is performed as given in 4.3 d) while either using AEL(*t* = 0,25 s), or AEL(t = *T*2(α)), depending on the time base. The angle of acceptance (as dimensions of the field of view) is varied between 1,5 mrad and 100 mrad in each dimension. Each field of view is associated to a certain value of *T*2 and therefore AEL(t = *T*2). The accessible emission is also determined for the respective field of view. The result of the process to vary the field of view is the “long-term” α that is associated to the field of view that produces the maximum ratio of AE to AEL. For the case of classification as Class 1, this process to determine the “long-term” α at the same time determines the value of *T*2(α). This “long-term” α is used for *C*6 for AEL(*t* = 0,25 s), or AEL(t = *T*2(α)), respectively, as well as the associated field of view to determine the AE for the comparison with these AEL. Following this step of the determination of the “long-term” α, all applicable shorter emission durations have to be analysed. For the analysis of emission durations less than 0,25 s, the “long-term” α is used to determine the appropriate *C*5 in the equalities of 4.3 f) 3). *T*2(α) is also relevant for the determination of *N* within *T*2(α) or the time base, whichever is shorter.		P

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
ZB.2.5	**Subclause 4.3 f) 3); groups of pulses with group duration longer than *T*i** For non-uniform repetitive pulse patterns, i.e. groups of pulses (see Figure ZB.2 for an example), when α > 5 mrad and the duration of the group of pulses is longer than *T*i, it is not clearly stated how the thermal additivity expressed by requirement 3) of 4.3 f) is applied. For *uniform* (i.e. constant peak power, duration and period) repetitive pulse trains, it is not necessary to analyse the emission patterns in terms of groupings of pulses. When individual pulses are close together, they are thermally grouped and thermally represent one “effective” pulse so that *C*5 also (additionally to analysing the pulse train based on the actual pulses and the average power) applies to these “effective” pulses, where *N* is the number of pulse groups within *T*2 or within the time base, whichever is shorter.  **Figure ZB.2 — Example of three groups of pulses (each group duration is longer than *T*i) where each group is considered as one “effective” pulse and *C*5 is applied to the AEL that applies to the group duration, where *C*5 is determined with the number of pulse groups within the evaluation duration (in the example of the figure *N* = 3)**		P
	For the analysis of pulse groups, the value of AELsingle is determined for the corresponding pulse group duration *t*group. For the determination of *C*5, *N* is the number of pulse groups within *T*2 or the time base, whichever is shorter. The respective value of *C*5 is applied to AELsingle to obtain AELs.p.train that limits the AE of the pulse groups, where AE is the sum of the energy of the pulses contained within the pulse group.		P

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
	For the application of *C*5 to groups of pulses, the AEL(*t*group) applicable to the group needs to be determined, as well as the energy per group (AEgroup). For groups of pulses where the peak power of the pulses within the group varies, the group duration is not well defined. In order to simplify the evaluation, *t*group can be set equal to the integration duration for which the energy per group (i.e. AEgroup) was determined; it is not necessary to determine the group duration based on the FWHM criterion, which for groups of pulses with varying peak power is not well defined. By setting *t*group equal to the integration duration that is used to determine AEgroup (expressed as energy), the application of *C*5 to groups of pulses is a simple extension of requirement 2) of 4.3. f) where the average power per group (equal to the energy within the averaging duration *t*average divided by the averaging duration) needs to be below the AEL(*t*average) determined for the duration over which the power was averaged (AEgroup and AEL(*t*group) expressed as power). As is common for the average power requirement, for irregular pulse trains, the averaging duration window (when expressed as energy: the integration duration window) has to be varied in temporal position and duration (for instance, if there are pulses with relatively low energy per pulse at the beginning or the end of the group of pulses, integration durations that exclude those low-energy pulses need to be considered also, not only the total group).		P

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
	If individual pulses have sufficient temporal spacing (period larger than *T*crit, see below), as a simplified analysis, they need not be considered for an analysis as a pulse group under 4.3 f) 3). The temporal spacing that is necessary for pulses to only be considered separate (and not analysed additionally as a group) depends on the angular subtense of the apparent source and the duration of the pulses *t*pulse within the group. Note that there can be several levels of grouping, so that individual elements (with pulse duration *t*) within the group could themselves be “effective pulses”, i.e. subgroups. When the — pulse group durations (*t*group) are between *T*i and 0,25 s, and — the angular subtense of the apparent source is larger than 5 mrad, and — the period of the pulses (see Figure ZB.2) is shorter than a critical period *T*crit (if *t*pulse < *T*i, the value of *t*pulse is set equal to *T*i; further, for the determination of *T*crit, αmax is determined for *t*pulse, not the group duration) where: for α ≤ αmax: *T*crit = 2 ·*t*pulse where *t*pulse is in seconds for α > αmax: *T*crit = 0,01 α ·*t*pulse0,5 where *t*pulse is in seconds, and α is in mrad, not being limited to αmax then these pulses constitute a pulse group which is treated as effective pulses and *C*5 (where *N* is the number of groups within the time base or *T*2, whichever is shorter) is applied to the AEL applicable to the pulse group. For the determination of AE, αmax is determined using the duration of the evaluated pulse group, *t*group. If one or more of the above conditions are not fulfilled, then the pulses within the group of pulses that is considered to be analysed as “effective pulse” need not be grouped, i.e. the group of pulses does not need to be analysed as one “effective” pulse. Note that if multiple pulses occur within *T*i, the rule as stated in 4.3 f) 3) applies in parallel, i.e. they are counted as a single pulse to determine *N* and the energies of the individual pulses that occur within *T*i are added to be compared to the AELs.p.train of *T*i where the corresponding *C*5 for emission durations *t* ≤ *T*i is applied.		P
ZB.2.6	**Subclause 4.3 f); simplifications**		N/A
	a) Constant peak power but shorter pulses Depending on the angular subtense of the apparent source, it can be the case that the value of *C*5 is more restrictive for pulses with pulse durations less than *T*i than for pulses with durations longer than *T*i which is against general biophysical principles for cases where the peak power is the same.		N/A
	b) Larger image of apparent source For emission durations exceeding *T*i, due to the step-function of *C*5 at 5 mrad and at αmax, the AEL (as a function of *C*5 and *C*6) can be more restrictive for larger values of the angular subtense of the apparent source as compared to smaller ones, which is contrary to general biophysical principles.		N/A

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
	c) Using a square aperture stop In some cases, such as 2D scanned laser beams, the use of a circular aperture stop to determine the accessible emission creates very complex pulse patterns. Due to the breakpoints in terms of pulse duration with step functions in the value of *C*5, it might not be apparent that the usage of a square aperture is acceptable as a simplified worst case analysis.		N/A
	d) Applicability of simplified default analysis For pulse durations longer than *T*i, the value of *C*5 is smaller (more restrictive) for angular subtense values α larger than 5 mrad compared to α ≤ 5 mrad. The assumption of α = 1,5 mrad is the basis of the simplified (default) evaluation. It is therefore not obvious if the simplified (default) analysis still applies in terms of being a restrictive simplifying analysis even for the case that the angular subtense of the apparent source is actually larger than 5 mrad, where *C*5 < 1.		N/A
	e) Determination of the most restrictive position For the extended analysis, it is necessary to vary the distance relative to the reference point to determine the most restrictive position. For each position in the beam, the accommodation is varied and the most restrictive image is determined. For determining the most restrictive image (where the ratio AE/AEL is maximum) at a given position, requirement 3) of 4.3 f) is not applied. Otherwise a blurred (larger) image of the apparent source, resulting from variation of the accommodation, could appear more restrictive, which is contrary to general biophysical principles. Once the most restrictive image (and associated α) is identified for each position in the beam, all three requirements of 4.3 f) are applied to determine the most restrictive position (identifying the position with the maximum ratio of AE/AEL) and the class of the product.		N/A

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
	f) Application of the total-on-time-pulse method; For regular pulse trains, as well as for varying pulse durations and/or varying period of pulses (but excluding strongly varying peak powers; see below), the total-on-time pulse (TOTP) method (see also IEC 60825-1 Edition 2.0 subclause 8.3 f) 3b)) may be used as an alternative to requirement 3) of 4.3 f), i.e. as an alternative to the application of *C*5 to the single pulse AEL, provided that αmax is determined for the TOTP (or using the worst case value of 100 mrad). This is more restrictive than the rules of 4.3 f) because it is equivalent to an unlimited *C*5 (*C*5 not limited to 0,2 or 0,4), and because the value of αmax is typically larger for the TOTP as compared to the value applicable to the single pulse. For the total-on-time-pulse (TOTP) method the following applies, as reproduced from Edition 2 of IEC 60825-1: The AEL is determined by the value of the TOTP, which is the sum of all pulse durations within the emission duration or *T*2, whichever is smaller. Pulses with durations shorter than *T*i are assigned pulse durations of *T*i. If two or more pulses occur within a duration of *T*i these pulse groups are assigned pulse durations of *T*i. For comparison with the AEL for the corresponding duration, all individual pulse energies are added. Note that the TOTP method in Edition 2 of IEC 60825-1 (incl. Corrigendum 1) was specified “For varying pulse widths or varying pulse intervals“ and did not refer to varying peak powers. For the case of strongly varying peak powers, the TOTP method is not applicable, as adding pulses to the pulse train with small peak powers and low contributing energy-per-pulse values might increase the AEL (by increasing the total-on-time) more than this increases the total energy, and thus would make the emission less critical as compared to an emission based on the pulses with the large peak power only.		N/A

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
	g) Varying peak power but constant pulse duration For varying peak power but constant pulse durations, requirement 3) of 4.3 f) can be applied by counting the pulses for the determination of *N* based on the relative peak power, i.e. *N* is increased by 1,0 for each pulse with the maximum peak power, and by a value of less than 1,0 for pulses with lower peak power, such as for a pulse with 70 % peak power compared to the maximum peak power in the pulse train, *N* is increased by 0,7. For this, based on the strong nonlinearity of thermally induced injury with temperature, it is justified not to count pulses with peak powers that are more than a factor of 10 below the pulse with the maximum peak power (i.e. less than 10 % of the maximum peak power). Note that the resulting AELs.p.train is applied to the pulse with the largest AE, i.e. the largest energy per pulse, and that the interpretation in this paragraph applies only for the case of pulse trains with constant pulse durations.		N/A
ZB.3	**Subclause 4.4 conventional lamp replacement (**IEC 60825**-**1**:**2014/ISH2:2017**)**		N/A
	This subclause ZB.3 contains the text of IEC 60825-1:2014/ISH2:2017 with some minor modifications for clarity. Subclause 4.4 introduces a criterion based on radiance, which is a quantity not normally determined for laser products. This interpretation clarifies the determination of radiance and the radiance limit. In this subclause ZB.3 of the Annex ZB, Subclause 4.4 is clarified.		N/A

IEC60825_1G – ATTACHMENT 1			
Clause	Requirement + Test	Result - Remark	Verdict
ZB.4	**Subclause 6.3.2 – safety interlocks** **Introduction** In this subclause, additional interpretations are provided, that were not contained in the IEC Interpretation Sheets, due to limitations on the length of the Interpretation Sheets. The requirements for safety interlocks that are provided with a deliberate override mechanism are specified in 6.3.2. The exception, described in 6.3.2 for automatically returning an overridden interlock to normal operation when an open door is closed, needs clarification. The portion of text that may cause confusion is: "If a deliberate override mechanism is provided, the manufacturer shall also provide adequate instructions about safe methods of working. It shall not be possible to leave the override in operation when the access panel is returned to its normal position. An exception to this requirement is allowed if selection of a service "override" mode automatically isolates the laser beam and prevents automatic resumption of operation of the machine. This exception also requires a lockable mode selector and requires a manual override to use the beam."		N/A

ZZ	**Annex ZZ** (informative)	P

Relationship between this European standard and the safety objectives of Directive 2014/35/EU [2014 OJ L96] aimed to be covered

P

This European Standard has been prepared under a Commission's standardization request relating to harmonized standards in the field of the Low Voltage Directive, M/511, to provide one voluntary means of conforming to safety objectives of Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits [2014 OJ L96].

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard given in Table ZZ.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding safety objectives of that Directive, and associated EFTA regulations.

Table ZZ.1 — Correspondence between this European standard and Annex I of Directive 2014/35/EU [2014 OJ L96]

Safety objectives of Directive 2014/35/EU	**Clause(s) / subclause(s) of this EN**	**Remarks / Notes**
1(a) (b)	Clause 7 (labelling) and Clause 8 (information for the user)	
1 (c)	Clause 5 (testing requirements) include intended use and maintenance	
2. (b) Protection against hazards arising from the electrical equipment with measures of a technical nature that ensure that radiation which would cause a danger is not produced.	Clauses 4–9	The scope of EN 60825-1 is limited to hazards from laser radiation to the eye or skin
3 (c)	Clause 5 (testing requirements) include single fault conditions	

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the product(s) falling within the scope of this standard.

---End of Attachment 1---