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CLASSIFICATION OF LASER ILLUMINATED LIGHT SOURCES UNDER IEC 60825-1 EDITION 3

Paper #401

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Abstract

IEC 60825-1 Edition 3 features a new subclause 4.4 which – provided that several requirements are fulfilled - permits classification of a laser illuminated light source as Class 1 under IEC 60825-1 and classification of the accessible light emission under the IEC 62471 series (Photobiological safety of lamps and lamp systems). The practical application of the requirements of this subclause is discussed, as well as the recent IEC Interpretation Sheet on subclause 4.4.

Caveat

The authors were actively involved in the development of subclause 4.4 of IEC 60825-1 Edition 3.0 as well as in the development of IEC 62471-5 Edition 1. It is emphasised that the content of these proceedings reflects the personal view of the authors and shall not be seen as official or generally accepted interpretation for the application of subclause 4.4 of IEC 60825-1.

Introduction

In 2014, the third edition of IEC 60825-1 was published [1]. One of the major revisions as compared to earlier editions was the introduction of subclause 4.4 which permitted the classification of the emission of a product under the lamp safety standard series IEC 62471 (a short overview of the series is given further below).

The amendment became necessary driven by technological evolution allowing to replace conventional lamps by lasers as the basic light source, such as in image projectors and car head lamps. The light emission in terms of radiance and beam size was equivalent to classical lamps, such as of xenon lamps; also the emission represents “white” light, i.e. broadband, typically achieved by laser incident on a phosphor converter. That is, the product as such, such as a cinema image projector, had the same projection optics (referred to as “lens”) and image formation technology, but the light was generated within the product employing a laser instead of a xenon lamp or other high intensity discharge lamps. While the same projector with a xenon lamp falls in the scope of IEC 62471 in terms of optical radiation safety, the laser illuminated projector was a laser product and falls in the scope of IEC 60825-1, which was inconsistent considering that the optical radiation emission was basically the same. Also in some countries, such as the USA, laser products are more heavily regulated as compared to lamp products. Besides questions of legal requirements and legal regulations, the main problem is that the laser classification system historically is based on the default of a collimated laser beam presenting a point source (minimal retinal image) while this is not the case for the light that is emitted for lighting or image projection. Also the default testing distance for lasers specified to be 100 mm from a given reference point is extremely restrictive. For instance, for lasers, the AEL for Class 3B is equal to 500 mW and when the power measured through a 7 mm aperture placed at 100 mm from the reference point is exceeded, the product is Class 4. The default reference point is the (possibly virtual) beam waist, which for image projectors is the exit pupil (see for instance IEC 62471-5 [2]) which for larger projectors is recessed within the projection lens. This results in a measurement position of the 7 mm aperture very close or in contact with the outer surface of the projection lens and with the AEL of 500 mW results in higher power cinema projectors to be laser Class 4 when classified under the laser safety standard. The associated low risk for retinal and skin injury is not proportionate the usual safety measured enforced for Class 4 laser products. Similar concerns are related to Class 3R and Class 3B laser products as projectors or car headlamps, which are in many countries not considered as appropriate to be sold as consumer products. The same product with equivalent radiance but xenon lamps instead of lasers, such as existing high-end image projectors and xenon high beam headlights in cars when classified under the laser standard do fall in those classes but with no known retinal injury [3]. This resulted in a strict and over-conservative framework for manufactures that want to offer solid light based devices.

The solution to this situation was that (when the product fulfils a number of criteria) the accessible emission can be classified under the lamp safety standard series

IEC 62471, while the product as such still remains the in the scope of IEC 60825-1 (in the same way that a DVD player is a laser product and is classified under IEC 60825-1, where no laser radiation is emitted). With this concept, one could imagine that the light emission of the product is "neglected" when it comes to determine the accessible emission and the class of the laser product. This approach usually results in the product to be classified as Class 1 laser product, and a certain risk group according to IEC 62471 series independently of the laser classification system. It is also possible that a product has multiple emission sources, where the emission that satisfies subclause 4.4 is classified under the IEC 62471 series, but there is for instance also a laser alignment pointer as part of the product that is a Class 2 laser, which makes the whole product then a Class 2 product (plus the risk group from the emission that satisfies subclause 4.4). For such a scenario it needs to be considered that emissions are only then treated independently when the beams are not collinear, i.e. when image of the apparent source of the emission do not overlap on the retina. When there is an overlap on the retina, the whole accessible emission (such as is also necessary for laser and broadband emission from LEDs that overlap on retina) need to be classified together, either under IEC 60825-1 or (provided that they combined comply with the requirements of subclause 4.4) under IEC 62471. This is also a difference to earlier editions where the classification of combined sources was not clear and lead to the interpretation that for a blue-laser pumped phosphor the blue emission is classified under the laser safety standard and the converted emission (the white light minus the blue peak) is classified under IEC 62471. Biophysically this is cannot be justified and therefore, in Edition 3 of IEC 60825-1 it was clarified (see also Interpretation Sheet IS-H 2 [4]) that combined emissions, including intended broadband emission, when coincident on the relevant tissue, need to be classified as additive.

IEC 62471 Series

IEC 62471 is a standard series entitled "Photobiological safety of lamps and lamp systems". The system for classification into "risk groups", from RG0 to RG3 has many similarities to the laser safety classes, particularly for the retinal thermal regime, where both RG2 and laser Class 2 have a time base of 0.25 seconds [5, 6]. The base standard is currently referred to as IEC 62471 and at the time of publication of this base standard there was no other part, i.e. it was not yet a series of standards. The base standard is currently revised and is to be republished as Edition 1 of IEC 62471-1, i.e. Part 1 of the IEC 62471 series. Part 5 of IEC 62471 was published in 2015 and applies to "Image projectors" [2]. Part 5 was already developed on the basis of subclause 4.4 of IEC 60825-1 Edition 3.0 and includes laser illuminated projectors in its scope.

IEC TR 62471-2 is a technical report that contains recommendations for labeling and user information for the different risk groups and emission limits; with the revision of IEC 62471 to be published as IEC 62471-1, Part 1 is likely to contain requirements for labeling and will then replace Part 2. While strictly speaking, IEC 62471 in terms of risk groups refers to lamps only, it is in practice also applied to classify lamp systems, i.e. to classify the complete product such as the luminaire. Other parts are currently in the state of development, such as Technical Report IEC TR 62471-3 which is planned to be a guide for measurements.

Requirements of Subclause 4.4

Overview

In principle, there are three requirements defined in IEC 60825-1 subclause 4.4 which all three need to be satisfied so that the accessible emission of the product can be neglected when it comes to classifying the laser product. These three requirements are listed in the following in a shortened version and are subsequently discussed in more detail. The three requirements (not organized in that distinct way in the standard) for the emission of a laser product to be classified under the IEC 62471 series are:

i) function as conventional lamp
ii) has a minimum angular subtense α of 5 mrad determined at 200 mm from the closest point of human access
iii) the maximum radiance accessible for normal operation and under consideration of reasonably foreseeable single faults does not exceed $1/\alpha$ MW m^{-2} sr^{-1} where α is given in units of radian

As can be seen from above requirements and the wording in IEC 60825-1, the degree of coherence is *not* a criterion if a product satisfies subclause 4.4. It is also permitted under subclause 4.4 that the emission is monochromatic if the specified requirements are satisfied, including that the product is designed to function as conventional lamp. The degree of coherence (neither spatial coherence nor temporal coherence, i.e. monochromaticity) is also no criterion for a laser product to fall in the scope of IEC 60825-1. The question if a product falls in the scope of IEC 60825-1 is simply if the source of radiation is a "laser" or not. For this reason it can also not be argued that a laser pumped phosphor does not fall in the scope of IEC 60825-1 "because it does not emit laser radiation, because it is broadband and non-coherent"; these are not criteria to decide if a product falls in the scope of

IEC 60825-1. As soon as the device that produces the optical radiation is a laser, it falls in the scope of IEC 60825-1, irrespective of the degree of coherence of the emission. Thus also a laser product that satisfies the requirements of subclause 4.4 still remains in the scope of IEC 60825-1. According to subclause 4.4, the product shall comply with the requirements of IEC 60825-1 for any laser radiation accessible during maintenance or service, which is relevant for instance for the labeling of access panels.

Requirement 1- Nature of product

The specific wording for *requirement 1* is:

"4.4 Laser products designed to function as conventional lamps
For laser products, except for toys, which are designed to function as conventional lamps and emit visible and near infrared optical radiation (400 nm to 1400 nm)…"

Thus, toys are generally excluded and the emission needs to be classified as laser radiation. It can be assumed here that the term "lamp" not only means the pure light source such as a xenon lamp, but also includes what is referred to as "lamp system" in the IEC 62471 series, i.e. the complete product.

Typical products that satisfy this first requirement (or criterion) are laser illuminated image projectors or lamp systems such as car headlamps where a blue laser is incident on a phosphor to produce white light. Since LEDs are also considered as "lamps", it can also be argued that when laser sources replace LEDs as source of optical radiation and the product function remains equivalent, that this product fulfils requirement 1. Laser image projectors with individual wavelengths (such as red, green and blue) also satisfy requirement 1 and it is specifically noted in subclause 4.4 that the emission may be monochromatic. An example of a product with monochromatic emission is a blue laser being coupled into a fibre where the whole fibre would emit blue light (with the end of the fibre capped) as used for effect lighting (an equivalent emission would be created from blue LEDs). Also it is not a requirement that the emission is in the visible wavelength range and that the laser only replaces lamps used for lighting: for instance, infrared LEDs or filtered tungsten halogen lamps are used for covertly illuminating scenes for security cameras. If an equivalent emission (for instance by using a diffusor) is created with an infrared laser as the source of radiation, it should also be possible to argue that condition 1 is fulfilled.

On the other hand, a collimated small-diameter laser beam that is scanned by a mirror will probably not be seen as to fulfil requirement 1 because the same emission cannot be produced with a lamp. Scanned emission as such is not specifically excluded from subclause 4.4, but it would need to be argued that the product is designed to replace conventional lamps, und usually lamps are not used in a scanning mode; an exception would be large diameter slowly scanning beams such as for lighthouse beacons. In this context it should be noted that for the case that scanning emission from a laser product can be argued to replace conventional lamps, the other two requirements in many cases are relatively restrictive in terms of the permitted emitted power.

Requirement 2 – minimum α of 5 mrad

Requirement 2 of a minimal angular subtense of the apparent source of 5 mrad is reflected in the middle part of the first sentence of subclause 4.4:

"For laser products, except for toys, which are designed to function as conventional lamps and emit visible and near infrared optical radiation (400 nm to 1400 nm) <u>from extended sources with angular subtense α greater than 5 mrad at 200 mm distance,…</u>"

Interpretation sheet I-SH 2 for IEC 60825-1 Edition 3 provides a number of relevant clarifications for this requirement. While the symbol α here - as generally in IEC 60825-1 - also means the angular subtense of the apparent source, there are some differences in the specifics, and for future amendments it might be prudent to use a different symbol in subclause 4.4. What is implied here in the same way as generally in IEC 60825-1, is that for the determination of the appropriate value of α (as well as the radiance criterion discussed below as requirement 3) is to vary the accommodation of the eye (or rather, the setup to determine α and radiance) to image different positions along the beam, from accommodation to infinity to the closest point of accommodation, which according to definition 3.10 of IEC 60825-1 is 100 mm as the near point. However, a near point of 200 mm when used for determination of α for subclause 4.4 should not make a difference, because the distance to the product is 200 mm and it is unlikely that there will be an external beam waist between the closest point of human access and 100 mm in front of the product. Contrary to some laser products that represent extended sources, for products that qualify for subclause 4.4 to function as conventional lamps, the location of the "apparent source" that is associated to the smallest value of α is usually apparent. Often a diffusor (such as a phosphor plate) is the actual optical source of the wavefronts that are emitted and accommodation to the diffusor will result in the smallest value of α. For image projectors, the location of the exit pupil (equivalent to a beam waist in the virtual beam inside of the projection lens) is generally considered as the "apparent source".

The distance of 200 mm is measured from the closest point of human access from the product (for example the projection lens barrel or glass surface of car head lamp), the same position where the radiance requirement (requirement 3) is determined from. It is also clarified in I-SH 2 that the criterion to determine the value of α is based on 50% points of the apparent source profile. That is, the "border" of the profile considered for the determination of the value of α is defined by the positions in the profile where the local radiance (or irradiance when analyzing the irradiance profile on a camera for instance) represents 50% of the peak radiance or irradiance, respectively (see Figure 1). This is in line with the definition of IEC 62471 and is somewhat more conservative as compared to the 1/e criterion, for instance.

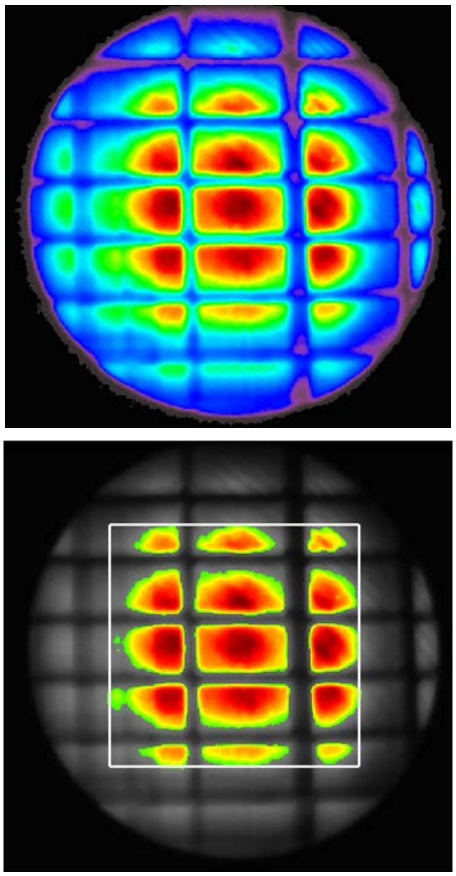

Figure 1. Example of a radiance profile of the exit pupil of a cinema image projector, as determined with a CCD camera (false colors); the original profile is shown as well as only the part that is above the 50% level. The white rectangle designates the outer envelope that is used to determine α.

For the case that the profile that is defined by the 50% borders results in individual partial sources (such as from an array), the value of α is determined for the *outer edge* of the profile. This means that individual parts of the profile are "permitted" to have smaller angular subtenses as 5 mrad. For the case of elongated outer envelopes of the profile of the apparent source, as is the case for the parameter α both in IEC 60825-1 as well as in IEC 62471, the arithmetic average is used.

The background of requirement 2 is to avoid that collimated beams and other "point" sources (such as laser pointers), are classified under the IEC 62471 series of standards where the basis of the dosimetry is the assumption of an extended, non-collimated source (for point sources, the concept of radiance breaks down, see for instance [7]). In IEC 62471-5 as well as in the draft IEC 62471-1, for the determination of radiance, it is permitted to use averaging field of views (also referred to as angle of acceptance) for continuous wave emissions of 11 mrad and for pulsed emissions an averaging angle of 5 mrad. To average with these angles over sources that are associated to collimated beams would result in an averaged radiance value that might be too low for an appropriate safety level to be associated when the averaged value is below the emission limits.

While coherence or lack thereof as such is not a criterion for the classification of a laser product's emission under the IEC 62471 series, the requirement for a minimum angular subtense implies also that the emission cannot be fully spatially coherent because in this case there would be either a very small beam waist or a very small divergence resulting in values of α smaller than 5 mrad.

That collimated laser beams with beam divergences less than 5 mrad do not qualify also is relevant for scanned beams where during the period where the beam is on the measurement aperture, accommodation to infinity results in a value of α equal to the far field divergence. That the image on the retina is scanned has no impact here because requirement 2 is independent of temporal considerations, as well as that requirement 3 (discussed below) applies to the momentary maximum.

It can be the case that for a laser illuminated phosphor, the laser spot on the diffusor is smaller than 1 mm, resulting in values of α of less than 5 mrad when determined at 200 mm from the diffusor. If such a product (i.e. without further projection optics that enlarge the value of α) is to be tested and classified based on IEC 60825-1 Edition 3.0, it would not fulfil the minimum source requirement. It was not the primary intent of requirement 2 to prevent such light sources from being classified as a lamp and the application of subclause 4.4 for diffuse emitters (i.e. fully lambertian) might well be defined differently in the next amendment of IEC 60825-1. However, in practice the current situation is not very restrictive, as the brightness permitted for Class 2 is considerable and if such light sources are intended to be used without projection optics in the luminaire (i.e. as bare bright light spot), it should be acceptable if the brightness is limited to that permitted for Class 2. On the other hand, higher power devices are intended almost exclusively to be used with projection optics, such as for a car headlamp high beam, and the projection optics result in a magnification of the apparent source and the final product then complies with requirement 2. For higher power emissions with the bare phosphor and no optics it is usually not that critical either, since usually these devices are just the bare laser illuminated phosphor with laser diode and cables (for instance as a replacement component for car headlamps) and then this device does not fall in the scope of IEC 60825-1 (see Clause 1 Scope and object):

"Laser products that are sold to other manufacturers for use as components of any system for subsequent sale are not subject to IEC 60825-1, since the final product will itself be subject to this standard."

Thus, for bare phosphor device and source angles less than 5 mrad, when in the lower power range can be classified as Class 2 (which for lighting purposes as bright spot is already quite bright) and when in the higher power range would usually be combined with projection optics in the final product which magnifies the source to larger than 5 mrad; and the bare diffusor device as a component is then not in the scope of IEC 60825-1.

Requirement 3 – radiance limit

Requirement 3, the radiance limit, is given in the latter half of the first sentence of subclause 4.4:

"…and having total (400 nm to 1400 nm) un-weighted peak radiance levels averaged with an acceptance angle of 5 mrad not exceeding L_T under operation and reasonably foreseeable single fault conditions, where $L_T = (1\ \text{MW}\cdot\text{m}^{-2}\cdot\text{sr}^{-1})/\alpha$ … For calculating L_T, the angular subtense α is expressed in radians and is determined at 200 mm from the closest point of human access. The value of α in the expression for L_T is limited to values between 0,005 rad and 0,1 rad so that for sources that subtend an angle of 0,005 rad the applicable radiance criterion equals 200 $\text{MW}\cdot\text{m}^{-2}\cdot\text{sr}^{-1}$, and for sources that are larger than 0,1 rad the applicable radiance criterion equals 10 $\text{MW}\cdot\text{m}^{-2}\cdot\text{sr}^{-1}$."

The value of "α" used in this requirement is the same as for requirement 2 discussed above, and it is also implied that the radiance measurement "accommodates" to produce the highest radiance, which will usually be associated with a "sharp image" of the apparent source such as the diffusor, which also has the smallest associated α for requirement 2.

In Note 1 of subclause 4.4 it is emphasized that this radiance criterion is not an exposure limit or emission limit, i.e. it is not a "safety limit" and it does not mean that when the radiance of the product is below the above limit that it is necessarily a "safe" product. The background of this criterion is simply to assure that very high radiance emissions, particularly from collimated laser beams remain to be classified as laser product and not under the lamp safety standard. But this does not necessarily mean that the product is associated to a "safe" risk group or is generally considered a "safe" product (for instance to be marketed as consumer product) – it could well be that a product satisfies the radiance criterion of subclause 4.4 but is then classified as Risk Group 3 under IEC 62471 and might not be appropriate, for instance, to be placed on the market as consumer product. Since the main potential hazard for the products under discussion is the retinal thermal hazard, it was found appropriate (even though the limit is not a safety limit) to scale the radiance criterion with the inverse of α in an equivalent way as the retinal safety limit in IEC 62471 is scaled inversely with α. As a rough guide, for an angular subtense of 0.01 rad (the approximate angular subtense of the sun as seen from the earth) the radiance limit equals 100 $\text{MW}\cdot\text{m}^{-2}\cdot\text{sr}^{-1}$, which is roughly ten times the integrated radiance of the sun in the wavelength range of 400 nm to 1400 nm.

It is important to note for requirement 3 that the "maximum" radiance has to be below the specified limits. The reference to "maximum" does not only imply that the controls of the device are adjusted to produce the maximum emission, it also means that the radiance profile of the apparent source is "scanned" with the acceptance angle of 5 mrad for hot-spots. Additionally, it also means maximum in terms of temporal variations, i.e. the *peak* radiance during a pulse needs to remain below the specified radiance limit as well as the radiance during a scan across the radiance measurement device, which is also expressed in the draft interpretation sheet I-SH 2.

The requirement to consider reasonably foreseeable single fault conditions for the determination of radiance (not specifically for the determination of α for requirement 2, by the way) can be seen in an equivalent way as for other cases where this is referred to in IEC 60825-1. For instance that the phosphor converter might be compromised either due to heat or mechanically and then the laser beam might be emitted from the device and the radiance criterion might not be satisfied anymore. The general methods of failure and risk analysis apply here as well, i.e. in order to determine if a fault has to be considered as reasonably foreseeable and the radiance emitted during the fault has to be below the stated limit. As is the general principle for risk analysis, both the probability (more correctly, the frequency in units of 1/hour) for the fault to occur is relevant as well as the severity of injury when the fault occurs. As also discussed in [8], when the risk for injury is relatively high, the probability of the fault to occur has to be low so that the overall risk as combination of probability and severity of injury is acceptable and the fault is not reasonably foreseeable (see also [9]). If the corresponding probability cannot be shown to be sufficiently small, additional engineering means need to be realized to reduce the risk to an acceptable level. For instance, when due to a fault of the conversion phosphor the laser beam would be emitted from the product, and it cannot be shown that the risk for injury is negligible or the probability of the fault to occur is correspondingly low, a detection device (such as based on the emission of white light) that reduces the laser power when the fault occurs can be used to reduce the overall risk to a sufficiently low level (see also IEC 61508 series for this kind of function safety approach). The reaction time of the reduction of emission needs to be sufficiently short and depends on the level of emission during the fault.

When subclause 4.4 was developed, it was based on the assumption that a small-beam collimated laser would not qualify as lamp replacement and therefore the diameter of the aperture stop for the determination of radiance was not specified, as for a typical emission field from lamps, the diameter of the aperture stop (the aperture on top of the imaging lens) is smaller than the radiation field and the diameter has no influence on the determined radiance. In order to also take care of the case that requirement 3 is applied to small collimated laser beams (which it should not be, because it is unlikely that such a product is considered to pass requirement 1) it was necessary to specify the diameter of the averaging aperture stop. A diameter of 7 mm as is usually used for laser safety measurements when the limit is specified as irradiance at the position of the eye was considered as to be *not* appropriate for the radiance measurement, as it would result in an “artificially” low radiance value (a factor 50 for a beam with 1 mm diameter). Therefore, in interpretation sheet I-SH 2, an averaging aperture stop diameter of 1 mm was specified for beam diameters less than 7 mm.

The details of radiance measurements [10] are not in the scope of this proceedings papers, but we would like to note that specified “theoretical” values or calculated values often err on the low side. For instance, for image projectors, the profile within the exit pupil is often not completely homogenous within the actual exit pupil. Consequently also the radiance when averaged over 5 mrad, which is smaller than the typical exit pupil, is larger than when the radiance is calculated by assuming a homogeneous profile within the exit pupil (averaging over the exit pupil). Thus a more detailed analysis is often necessary when approximate values approach the specified limits.

When the spectral distribution can be controlled, such as is the case for image projectors where different colors can be set, CCD cameras (laser beam profiling cameras) can be used to measure radiance. In this case, the CCD camera is placed in the image plane of a lens and can be calibrated for each color by also measuring the power through the aperture stop with a radiometer. The effect of filters to control the exposure level of the camera need to be considered. In this way, the radiance profile for the three colors can be determined separately and then added together. The analysis as to be performed with a 5 mrad averaging angle of acceptance (field stop) can be done conveniently with a “software” field stop that integrates the power within the field stop; division by the area of the field stop results in averaged irradiance at the CCD camera, which when divided by the solid angle subtended by the aperture stop as seen from the CCD camera results in radiance averaged over 5 mrad (see also graphics in reference [7]).

If the spectral emission cannot be controlled and if it is broadband, a CCD camera with varying sensitivity for different wavelengths is usually not appropriate. The more generally valid option is to place the input optics of a spectro-radiometer in the image plane and choose the focal length of the lens such that 5 mrad field stop in the image plane is smaller than the input optics of the spectrometer (such as the opening in an integrating sphere). This approach has the significant advantage that the measurement of local irradiance is possible in a spectrally resolved way and also that generally with a good spectro-radiometer the uncertainty is smaller as compared to a CCD camera. The disadvantage is that the diameter of the field stop is typically relatively small so that there is risk for error when the diameter does not result in an angular subtense of 5 mrad and also the work is more tedious, because the profile of the apparent source needs to be scanned for hot-spots, i.e. the location of the field stop (and input optics of the spectro-radiometer) needs to be varied in the image plane to search for the maximum.

Labels

In subclause 4.4, the following requirement regarding labelling is given:

“Such a product shall be assigned a risk group under the IEC 62471 series of standards and shall contain a label stating the risk group as well as the laser product classification (including Class 1 if applicable) and applicable warnings.”

This means that for the case of classification as Class 1, contrary to a “normal” Class 1 laser product where placing the Class 1 label on the product is optional, for a product with light emission that is excluded under subclause 4.4, the laser Class label is mandatory, additional to the label of the Risk Group according to the IEC 62471 series. Since in the current edition of IEC 62471 no requirement of a label stating the risk group is given, the above text of subclause 4.4 is relevant since it requires a label stating the risk group in any case.

Summary

In this paper, practical aspects of the classification of the emission of laser products replacing lamps based on subclause 4.4 of IEC 60825-1 are discussed. The content of the draft Interpretation Sheet I-SH 2 for IEC 60825-1 Edition 3.0 is also considered.

The main issues are:

- When subclause 4.4 is applied, the emission can be "neglected" for classification as laser product and the emission is classified under the IEC 62471 series.
- The product still remains in the scope of IEC 60825-1 and when no other laser radiation is emitted, is classified as Class 1.
- The degree of coherence is not a requirement neither generally for inclusion in the scope of IEC 60825-1 nor for the application of subclause 4.4.
- It is not necessary that the emission is broadband, it may be monochromatic if all other criteria are fulfilled.
- Application of subclause 4.4 is not mandatory; it is still possible to classify the emission of a product that satisfies the requirements of subclause 4.4 as before; however, it is required that all the emission that is coincident on the retina is considered as accessible emission in this case (including for instance when the emission originates from LEDs)
- The radiance limit given in subclause 4.4 is not a safety limit.
- The radiance limit shall not be exceeded including reasonably foreseeable single fault conditions and has to be considered as a general upper limit, i.e. also for momentary peak radiance values during pulses.
- Labeling of the risk group and laser class is mandatory even for low risk groups or laser classes.

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Meet the Authors

Karl Schulmeister, PhD, is a consultant on laser and broadband radiation safety at the Seibersdorf Laboratories, where also a specialized accredited test house is operated. Karl is a member of the ICNIRP Scientific Expert Group and liaison between IEC TC 76 and ICNIRP. He served as project leader for the development of IEC 60825-1 Edition 3 and currently coordinates the efforts to publish Interpretation Sheets for IEC 60825-1. He was also a member of the CIE committee that originally developed the text for IEC 62471. The research in his group over the last ten years concentrated on thermally induced injury that also provided the scientific background for amending the spot size dependence and multiple pulse rules of the retinal thermal limits.

Jan Daem is an Optical radiation safety expert and ECO officer at BARCO and Chairman of the Laser Illuminated Projector Association (LIPA). Jan Daem is currently focused on the worldwide introduction of laser illuminated projector systems. In this position as well as Chairman of LIPA, he is ensuring safety standards and regulations are created without unnecessarily-strict restrictions upon manufacturers and without undue safety hazards for consumers and AV professionals. The activities include managing a worldwide team of professionals evaluating the light emitted from projectors, as well as interacting with regulatory officials at region, state and EU Commission levels. Jan is also very active on the IEC TC-76 Committees.