Eye Safety Risk Assessment of Infrared Emitting Diodes According IEC 62471 (based on CIE S009)

INTRODUCTION

Product safety legislation (e.g. general product safety laws as in Europe the “low voltage- or machinery directives”) requires conformity with “essential requirements”, for instance, protection of health and safety that goods must meet when placed on the market. In this context, compliance with product safety standards for optical sources, such as the standards IEC 60825-1 and IEC 62471, should provide presumption of conformity with these “essential requirements”. The compliance is guaranteed when the goods are classified according the standards as safe, expressed as with e.g. “class 1” or “exempt” for optical sources.

Therefore the operating conditions and the optical and mechanical construction of the final goods define the risk. The risk assessment of LED (1) applications is not directly related to the LED component.

The risk assessment and classification is to be done with the final product, not with the built-in component. In IEC/EN60825-1 that is expressed by “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”. IEC 62471 demands a risk assessment of the lamp (LED) itself. This may be not sufficient for the application, especially when LED arrays are used.

RISK ASSESSMENT FOR LED - APPLICATIONS

Optical sources and optical radiation are covered by different regulative standards. After the latest changes in 2011 the eye safety standards compiled in the following table are applicable for LEDs.

Note

(1) We are using sometimes in our documentation the abbreviation LED and the word light emitting diode also for infrared emitting diodes (IRED). Whenever the term LED is used, IREDs are included when not otherwise noted. That is common usage but not in agreement with IEC 60050-845

EXAMPLE OF APPLICATIONS COVERED BY DIFFERENT OPTICAL RADIATION SAFETY

	IEC/EN 60825-1 (2007-03) (1)	IEC 62471 (2006) (2)	DIRECTIVE 2006/25/EC (3)
Fiber optical components	Applicable for laser sources only	x	w
Free air communication IR - remote control (TV, audio, video) IR - communication (IrDA®, home)	Applicable for laser sources only	x	w
Lighting (visible and IR), lamps	-	x	w
IR - photo flash (traffic enforcement)	-	x	w
IR - light barriers	-	x	w
LED indicators	-	x	w
UV - lamps	-	x	w

Notes

- w: for workers environment only

(1) **IEC/EN 60825-1 (2007-03), DIN EN 60825-1 (2008-05)**
“SAFETY OF LASER PRODUCTS - Part 1: Equipment classification and requirements”

(2) **IEC 62471 (2006)**
“Photobiological Safety of Lamps and Lamp Systems”

(3) **DIRECTIVE 2006/25/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL**
of 5 April 2006
on the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation) (19th individual directive within the meaning of article 16(1) of directive 89/391/EEC)

THE DIFFERENT EYE SAFETY STANDARDS FOR LEDS

The standard **IEC (EN DIN) 60825-1** "SAFETY OF LASER PRODUCTS - Part 1: equipment classification and requirements", is applicable to safety of laser products emitting (coherent) laser radiation in the wavelength range 180 nm to 1 mm. In previous editions, LEDs were included in the scope of this standard, and were also included in other parts of the IEC 60825 series, as e.g. in IEC 60825 - Part 12, "Safety of free space optical communication systems used for transmission of information". Currently the standardization philosophy changed, that with the development of lamp safety standards, optical radiation safety of LEDs in general can be more appropriately addressed by lamp safety standards. IEC 62471 now is to be applied to determine the risk group of an LED or product incorporating one or more LEDs.

IEC 60825-1 does not cover the LEDs emitting radiation for indication, illumination, lighting, or data transmission anymore.

However, LEDs formerly assessed as "class 1" of this standard will be safe also when rated by the new standard ("exempt").

A general standard for the safety of incoherent sources was already in the past the **CIE S009** ("Photobiological Safety of Lamps and Lamp Systems"), which later was published as a new common ISO/IEC standard **IEC 62471**. This is equivalent but not in all items identical with the **European Directive 2006/25/EC** with the long title mentioned already above.

The European edition of IEC 62471 as EN 62471 was delayed for some time. A new edition of EN 62471 published in the meantime and a technical report published as part 2: Guidance on manufacturing requirements relating to non-laser optical radiation safety with the new title IEC 62471-2 Ed. 1/TR are available. In Germany this part 2 is published also as technical report as "Beiblatt 1" to the basic standard.

IEC 62471 according the title "Photobiological Safety of Lamps and Lamp Systems" lets assume not only to cover the final product as IEC 60825-1 but especially the lamp. The original text, chapter 6 of IEC 62471 says it requires in first order the classification of the lamp: "This clause is concerned with lamp classification. However a similar classification system could be applicable to luminaires or other systems containing operating lamps".

While in case of e.g. incandescent lamps where e.g. in most cases just one single conventional lamp (bulb) is used for a luminaire the risk assessment can refer to the lamp. In case of LEDs with many LEDs e.g. combined in one luminaire this may be different.

LED manufacturers usually do not know the future application and would have to apply any limit set. Thus, since the risk group allocation bases in any case on the most restrictive limits, the result might be inappropriate for the future application or overly restrictive. As the laser safety standard IEC 60825-1 also IEC 62471 is to be interpreted like "The final product will itself be subject to this standard". Only this is strictly in agreement with general product safety laws (e.g. in Europe the "low voltage- or machinery directives").

For instance, the EU product safety legislation requires conformity with "essential requirements", e.g., protection of health and safety that goods must meet when they are placed on the common market. In this context, compliance with product safety standards, such as the standards IEC 60825-1 and IEC 62471, should provide presumption of conformity with these "essential requirements".

CLASSIFICATION

IREDs

Most IREDs are emitting in the 800 nm to 960 nm range. Radiation within these wavelengths causes a thermal retina hazard and thermal injury risk of the cornea and possible delayed effects on the lens of the eye (cataractogenesis). In general the IEC 60825-1 is more restrictive in case of the thermal retinal hazard; the cornea/lens limits with the given conditions can be found only in IEC 62471 and in the European Directive 2006/25/EC.

In the past IREDs were classified by the simplified method according IEC 60825-1 comparing the maximum intensity emitted under absolute maximum rating conditions. When the intensity was above that limit, the source size had to be taken into account. With that none of the currently available (July/2008) Vishay IREDs violate the class 1 limit. In case of IEC 62471 and in the European Directive 2006/25/EC all Vishay IREDs are inside the exempt conditions. Only with arrays care must be taken not to violate the cornea/lens limits.

LEDs

Diode emitters in the visible spectrum cover the wavelength range from 400 nm to 780 nm including also wide band white LEDs. LEDs in the visible spectrum are used for lighting, signaling, or as indicators. Therefore the risk assessment is according IEC 62471 and in the European Directive 2006/25/EC.

Here the blue light hazard with the wavelength depending function B (λ) is the limiting factor still on the red side of the spectrum. It has to be taken into account up to a wavelength of 700 nm.

The intensity specification of visible LEDs is done in terms of photometric units as Candela (cd). Due to the strong variation of the ratio to the radiometric units used for defining the limits this is more complicated or even confusing for the normal electrical engineer.

Nearly all LEDs are far below the Exempt limits. However, care should be taken on the short wavelength side of the spectrum. Therefore a general statement as for IREDs cannot be given.

Vishay supplies all necessary data for the risk assessment in the data sheet and on request, in case it is not published there. Either via the sales channel or simply the technical support box on the website this data will be available on request.

LEDs are removed from IEC 60825-1. LEDs are to be assessed according IEC 62471 and European Directive 2006/25/EC. All LEDs are moved to the eye safety standard for artificial non coherent sources IEC 62471.

SUMMARY OF INTENSITY/WAVELENGTH DATA ACCORDING EXEMPT GROUP OF IEC 62471		
PART NUMBER	**VIRTUAL SOURCE SIZE d (mm)**	**WAVELENGTH / MAXIMUM INTENSITY AT ABSOLUTE MAX. RATINGS**
CQY36N	1.2	950 nm / 2.1 mW/sr
CQY37N	1.2	950 nm / 11 mW/sr
TSAL4400	1.9	940 nm / 80 mW/sr
TSAL5100	3.7	940 nm / 400 mW/sr
TSAL5300	2.3	940 nm / 150 mW/sr
TSAL6100	3.7	940 nm / 400 mW/sr
TSAL6200	2.4	940 nm / 200 mW/sr
TSAL6400	2.2	940 nm / 125 mW/sr
TSAL7200	2.4	940 nm / 200 mW/sr
TSAL7300	2.3	940 nm / 150 mW/sr
TSAL7400	2.2	940 nm / 125 mW/sr
TSAL7600	1.8	940 nm / 75 mW/sr
TSFF5210	3.7	870 nm / 360 mW/sr
TSFF5410	2.1	870 nm / 135 mW/sr
TSFF5510	-	870 nm / 48 mW/sr
TSFF6210	3.7	870 nm / 450 mW/sr
TSFF6410	2.1	870 nm / 135 mW/sr
TSHA4400	1.8	875 nm / 60 mW/sr
TSHA4401	1.8	875 nm / 60 mW/sr
TSHA5200	3.7	875 nm / 125 mW/sr
TSHA5201	3.7	875 nm / 125 mW/sr
TSHA5202	3.7	875 nm / 125 mW/sr
TSHA5203	3.7	875 nm / 125 mW/sr
TSHA5500	2.2	875 nm / 48 mW/sr
TSHA6200	3.7	875 nm / 125 mW/sr
TSHA6201	3.7	875 nm / 125 mW/sr
TSHA6202	3.7	875 nm / 125 mW/sr
TSHA6203	3.7	875 nm / 125 mW/sr
TSHA6500	2.2	875 nm / 48 mW/sr
TSHF4410	1.9	890 nm / 120 mW/sr
TSHF5210	3.7	890 nm / 360 mW/sr
TSHF5410	2.1	890 nm / 135 mW/sr
TSHF6210	3.7	890 nm / 360 mW/sr
TSHF6410	2.1	890 nm / 135 mW/sr
TSHG5210	3.7	850 nm / 420 mW/sr
TSHG5410	2.1	850 nm / 135 mW/sr
TSHG5510	-	830 nm / 54 mW/sr
TSHG6200	3.7	850 nm / 360 mW/sr
TSHG6210	3.7	850 nm / 420 mW/sr
TSHG6400	3.7	850 nm / 135 mW/sr
TSHG6410	2.1	850 nm / 135 mW/sr
TSHG8200	3.7	830 nm / 360 mW/sr
TSHG8400	2.1	830 nm / 135 mW/sr

SUMMARY OF INTENSITY/WAVELENGTH DATA ACCORDING EXEMPT GROUP OF IEC 62471		
PART NUMBER	**VIRTUAL SOURCE SIZE d (mm)**	**WAVELENGTH / MAXIMUM INTENSITY AT ABSOLUTE MAX. RATINGS**
TSKS5400	1.2	950 nm / 7 mW/sr
TSKS5400S	1.2	950 nm / 7 mW/sr
TSMF1000	1.2	890 nm / 13 mW/sr
TSMF1020	1.2	890 nm / 13 mW/sr
TSMF1030	1.2	890 nm / 13 mW/sr
TSML1000	1.2	940 nm / 15 mW/sr
TSML1020	1.2	940 nm / 15 mW/sr
TSML1030	1.2	940 nm / 15 mW/sr
TSML1040	1.2	940 nm / 15 mW/sr
TSPF6200	-	890 nm / 90 mW/sr
TSSF4500	2.1	890 nm / 50 mW/sr
TSSS2600	2	950 nm / 3 mW/sr
TSTA7100	1.5	875 nm / 100 mW/sr
TSTA7300	1	875 nm / 50 mW/sr
TSTA7500	0.5	875 nm / 16 mW/sr
TSTS7100	1.5	950 nm / 50 mW/sr
TSTS7300	1	950 nm / 32 mW/sr
TSTS7500	0.5	950 nm / 8 mW/sr
TSUS3400	2.1	950 nm / 35 mW/sr
TSUS4300	2.1	950 nm / 35 mW/sr
TSUS4400	2.1	950 nm / 35 mW/sr
TSUS5200	3.8	950 nm / 50 mW/sr
TSUS5201	3.8	950 nm / 50 mW/sr
TSUS5202	3.8	950 nm / 50 mW/sr
TSUS5400	2.9	950 nm / 35 mW/sr
TSUS5401	2.9	950 nm / 35 mW/sr
TSUS5402	2.9	950 nm / 35 mW/sr
VSLB3940	2.0	940 nm / 110 mW/sr
VSLB3948	2.0	940 nm / 110 mW/sr
VSLB4940	-	940 nm / 110 mW/sr
VSLB9530S	-	940 nm / 95 mW/sr
VSLY3850	-	850 nm / 105 mW/sr
VSLY3943	-	940 nm / 120 mW/sr
VSLY5850	-	850 nm / 900 mW/sr
VSLY5940	-	940 nm / 900 mW/sr
VSMB10940	-	940 nm / 4.8 mW/sr
VSMB11940	-	940 nm / 4.8 mW/sr
VSMB14942	-	940 nm / 42 mW/sr
VSMB1940	-	940 nm / 12 mW/sr
VSMB1940X01	0.5	940 nm / 12 mW/sr
VSMB2000X01	1.5	940 nm / 60 mW/sr
VSMB2020X01	1.5	940 nm / 60 mW/sr
VSMB294008RG	-	940 nm / 90 mW/sr
VSMB2943RGX01	-	940 nm / 30 mW/sr
VSMB2943SLX01	-	940 nm / 30 mW/sr
VSMB2948	-	940 nm / 30 mW/sr
VSMB2948SL	-	940 nm / 30 mW/sr
VSMB3940X01	0.5	940 nm / 21 mW/sr

SUMMARY OF INTENSITY/WAVELENGTH DATA ACCORDING EXEMPT GROUP OF IEC 62471		
PART NUMBER	**VIRTUAL SOURCE SIZE d (mm)**	**WAVELENGTH / MAXIMUM INTENSITY AT ABSOLUTE MAX. RATINGS**
VSMF2890GX01	1.5	890 nm / 60 mW/sr
VSMF2890RGX01	1.5	890 nm / 60 mW/sr
VSMF2893RGX01	-	890 nm / 30 mW/sr
VSMF2893SLX01	-	890 nm / 30 mW/sr
VSMF3710	0.44	890 nm / 22 mW/sr
VSMF4710	0.44	870 nm / 22 mW/sr
VSMF4720	0.67	870 nm / 30 mW/sr
VSMG10850	-	850 nm / 5.85 mW/sr
VSMG2000X01	1.5	850 nm / 60 mW/sr
VSMG2020X01	1.5	850 nm / 60 mW/sr
VSMG2700	0.44	830 nm / 22 mW/sr
VSMG2720	0.67	830 nm / 24 mW/sr
VSMG285011RG	-	850 nm / 60 mW/sr
VSMG3700	0.44	850 nm / 22 mW/sr
VSML3710	0.44	940 nm / 20 mW/sr
VSMS3700	0.5	950 nm / 8 mW/sr
VSMY14940	-	940 nm / 120 mW/sr
VSMY1850X01	0.5	850 nm / 15 mW/sr
VSMY1850ITX01	0.5	850 nm / 15 mW/sr
VSMY1940X01	-	940 nm / 15 mW/sr
VSMY1940ITX01	-	940 nm / 15 mW/sr
VSMY2850	1.5	850 nm / 150 mW/sr
VSMY2850RGX01	-	850 nm / 210 mW/sr
VSMY2853RGX01	-	850 nm / 70 mW/sr
VSMY2940	-	940 nm / 195 mW/sr
VSMY2940RGX01	-	940 nm / 215 mW/sr
VSMY2941RGX01	-	940 nm / 236 mW/sr
VSMY2943RG	-	940 nm / 75 mW/sr
VSMY2943SLX01	-	940 nm / 75 mW/sr
VSMY3850	0.44	850 nm / 25 mW/sr
VSMY3940X01	-	940 nm / 24 mW/sr
VSMY7850X01	-	850 nm / 390 mW/sr
VSMY7852X01	-	850 nm / 90 mW/sr
VSMY98145DS	-	810 nm / 800 mW/sr
VSMY98525DS	-	850 nm / 1600 mW/sr
VSMY98545	-	850 nm / 550 mW/sr
VSMY98545ADS	-	850 nm / 1000 mW/sr
VSMY98545DS	-	850 nm / 900 mW/sr
VSMY9857535	-	850 nm / 290 mW/sr
VSMY98575ADS	-	850 nm / 500 mW/sr
VSMY99445DS	-	940 nm / 900 mW/sr
VCNL4100	-	940 nm / 100 mW/sr
VCNL4200	-	940 nm / 100 mW/sr

Note

- All listed diode emitters are inside exempt group of IEC 62471

IEC 62471 AND EU DIRECTIVE 2006/25/EC

For all applications the standard IEC 62471 is applicable.

This standard for incoherent sources replaces for LEDs the laser standard IEC DIN EN 60825-1.

In case of IR - Emitters the dominating limit is the cornea/lens risk in the wavelength range from 780 nm to 3000 nm. This limits the irradiance to E_e = 100 W/m^2 which is expressed as intensity a value of **I_e = 4 W/sr** with the measurement condition of that standard with 0.2 m distance in mind ($I_e = E_e \times r^2$).

Evaluating the other limiting conditions as the thermal retinal risk and blue light hazard result in not limiting higher values for wavelengths $\lambda > 850$ nm and therefore are not to be taken into account. Only for $\lambda = 830$ nm a little reduction to **I_e = 3.77 W/sr** is given by the thermal risk.

This is still far above of the emitted intensities of IREDs covered by the Vishay datasheets.