Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

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Abstract:
Purpose:

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Eye Safety for laser and lamp

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Sponsored by NICT (National Institute of Information and Communication Technology)

VLCC Visible Light Communications Consortium

ICSA 光無線通信システム推進協議会 Infrared Communication Systems Association

Two Organizations for Safety:

- **IEC** (International Electrotechnical Commission): Safety of Laser Products

  ...excluded LED.(working with CIE for LED)

- **CIE** (International Commission on Illumination=Commission Internationale de Eclairage):Photobiological safety of lamps and lamp systems….included LED.

IEC60825 Series
Safety of Laser Products

No	Title	Type
1	Equipment Classification and Requirements	Standard
2	Safety of Optical Fiber Communication Systems	Standard
3	Guidance of Laser Displays and Shows	TR
4	Laser Guards	Standard
5	Manufacturer's Checklist for IEC60825-1	TR
8	Guidelines for the safe use of Medical Laser Equipment	TR
9	Compilation of Maximum Permissible Exposure to incoherent Optical Radiation.	TR
10	Laser safety application guidelines and explanatory notes	TR
12	Safety of Free Space Optical Communication Systems used for Transmission of Information	Standard
14	A User's Guide	TR

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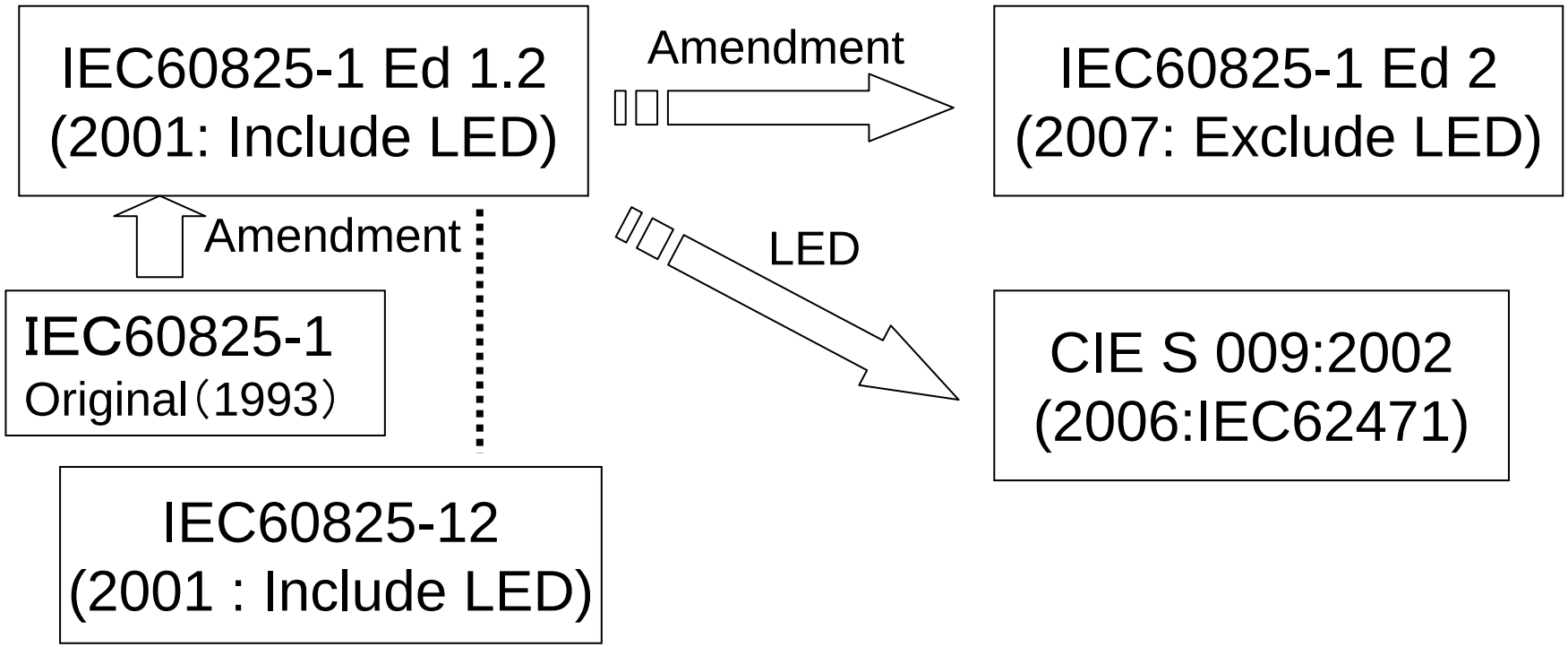
IEC60825-1 and CIE S 009:2002



CIE included LED (CIE S 009) as "Photobiological safety of lamps and lamp systems" in 2006. This is a double logo (CIE, IEC) standard. Then, IEC amended IEC60825-1 to exclude LED in 2007

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IEC60825-1:Safety of Laser Products Equipment classification and requirements

Classification Rules:

- Wavelength
- Source Size
- Time duration
- Repetitive Pulse

Laser Product: Accessible Emission Limits (AEL) are given for each class:

- Classes are ranked in increasing order of hazard (AEL):

  1, 2, 1M, 2M, 3R, 3B, 4,

- Each class has each level of AEL.

Accessible Emission is level of radiation in order to determine the class of the laser product.

Laser Product: Classification

Class 1

Safe during use, including long-term direct intrabeam viewing ,even when exposure occur while using optical viewing instruments (eye loupes or binoculars).

Label: **CLASS 1 LASER PRODUCT**

Class 1M

Safe during use, including long-term direct intrabeam viewing for the naked eye (unaided eye), but eye injury may occur with using optical viewing instruments (eye loupes or binoculars).

Label**:** **LASER RADIATION**
DO NOT VIEW DIRECTLY WITH OPTICAL INSTRUMENTS
CLASS 1M LASER PRODUCT

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Class 2

Laser products that emit visible radiation in the wavelength from 400 nm to 700 nm that are safe for momentary exposures but can be hazardous for deliberate staring into the beam. The time base of 0.25 s is inherent in the definition of the class.

Label:

LASER RADIATION
DO NOT STARE INTO BEAM
CLASS 2 LASER PRODUCT

Class 2M

Laser products that emit visible laser beams and are safe for short time exposure only for the naked eye (unaided eye). Eye injury may occur with using optical viewing instruments (eye lopues or binoculars).

Label**:**

LASER RADIATION
DO NOT STARE INTO THE BEAM OR VIEW
DIRECTLY WITH OPTICAL INSTRUMENTS
CLASS 2M LASER PRODUCT

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Class 3R

Laser Product that emit radiation that can exceed the MPE under direct intrabeam viewing, but the risk of injury in most cases is relatively low the AEL for Class 3R is only 5 times the AEL of Class 2 or the AEL of Class 1. Dazzle, flash-blindness and afterimages may be caused by a beam from a Class 3R laser product in the visible wavelength range, particularly under low ambient light conditions.

Label:

LASER RADIATION
AVOID DIRECT EYE EXPOSURE
CLASS 3R LASER PRODUCT

Class 3B

Laser product that are normally hazardous when intrabeam ocular exposure occurs including accidental short time exposure. Viewing diffuse reflection is normally safe. Class 3B lasers may produce minor skin injuries or even pose a risk of igniting flammable materials.

Label:

LASER RADIATION
AVOID EXPOSURE TO BEAM
CLASS 3B LASER PRODUCT

MPE (Maximum Permissible Exposure) represent the maximum level of laser radiation to which the eye or skin can be exposed without consequential injury. AEL is derived from MPE.

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Class 4

Laser Products for which intrabeam viewing and skin exposure is hazardous and for which the viewing of diffuse reflection may be hazardous. These lasers also often represent a fire hazard.

Label:

LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT

Repetitive Pulse

In the case of repetitive pulsed lasers, the different AEL is applied as follows;

- The exposure from any single pulse shall not exceed the AEL for a single pulse.
- The average power for a pulse train of emission duration shall not exceed the power corresponding to the AEL for a single pulse duration.

CIE S 009:2002（IEC62471）Photobiological safety of lamps and lamp systems

Purpose:

The evaluation and control of optical radiation hazards from lamps and lamp systems is a far more complicated subject compared to similar tasks for the laser products and systems.

--First:

To evaluate a broad-band optical source (compared to a laser beam), such as an arc lamp, an incandescent lamp, a fluorescent lamp, an array of lamps, LED lamp or a lamp system, it is necessary to determine the spectral distribution of optical radiation emitted from the source at the point or points of nearest human sources. It includes LEDs but excluding lasers, in the wavelength from 200nm to 3000nm.

--Second:

The size, or projected size, of the source must be characterized in the retinal hazard spectral region. The retina absorbs the range of wavelength from 380nm to 1400nm.

--Third:

It is necessary to determine the variation of effective radiance with distance. (Measurement techniques with risk group classification are required.)

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Hazard Exposure Limits (EL'S)

1. **Exposure limits:**

   The exposure limits (EL's) represent conditions under which it is believed that nearly all individuals in the vicinity of lamps and lamp systems may be exposed without adverse health effects. The exposure limits in this standard apply to continuous sources where the exposure duration is not less than 0.01 ms and not more than any 8-hour period.

2. **Retinal exposure limits**.

   Specific factors are involved in the determination and application of retinal exposure limits. The radiant flux that enters the eye and is absorbed by the retina (380nm to 1400nm) is proportional to the pupil area. It is known that the pupil diameter decreases from around 7mm diameter at very low luminance to about 2mm at very high luminance.

3. **Angular subtense**. (Visual angle subtended by the apparent source at an observer's eye)

   For radiation in the wavelength range 380nm to 1400nm the area of the retina irradiated is an important element in determining the EL's for both the blue light and retinal thermal hazards.

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Exposure Limits Parameters:

1. Actinic UV hazard exposure limit for the skin and eye
2. Near-UV hazard exposure limit for the eye
3. Retinal blue light hazard exposure limit
4. Retinal thermal hazard exposure limit
5. Infrared radiation hazard exposure limits for the eye

Lamp Classification:

For lamps intended for the classification: general lighting service, the hazard values shall be reported at a distance which produces an illuminance of 500lux, but not at a distance less than 200mm.

Continuous wave lamps:

1. Exempt group:

The philosophical basis for the exempt group classification is that the lamp does not pose any photobiological hazard for the end points . This requirement is met by any lamp that does not pose:

- an actinic ultraviolet hazard within 8-hours exposure (30000 s)
- a near-UV hazard within 1000 s (about 16 min)
- a retinal blue light-hazard within 10000 s (about 2.8 h)
- a retina thermal hazard within 10 s
- an infrared radiation hazard for the eye within 1000 s (about 2.8 h)

These lamps are in the Exempt Group.

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2. Risk Group 1 (Low-Risk)

The philosophical basis for this classification is that the lamp does not pose a hazard due to normal behavioral limitations on exposure. This requirement is met by any lamp that exceeds the limits for the Exepmt Group but that does not pose:

- an actinic ultraviolet hazard within 10000 s (about 2.8 h)
- a near ultraviolet hazard within 300 s
- a retina blue-light hazard within 100 s
- a retina thermal hazard within 10 s
- an infrared radiation hazard for the eye within 100 s

These lamps are in Risk Group 1 (Low-Risk).

3. Risk Group 2 (Moderate-Risk)

The philosophical basis for the Risk Group 2 (Moderate-Risk) classification is that the lamp does not pose a hazard due to the aversion response to very bright light source or due to thermal discomfort. This requirement is met by any lamp that exceeds the limits for Risk Group 1 (Low-Risk), bit that does not pose:

- an actinic ultraviolet hazard within 1000 s exposure
- a near ultraviolet hazard within 100 s
- a retinal blue-light hazard within 0.25 s (aversion response)
- a retina thermal hazard within 0.25 s (aversion response)
- an infrared radiation hazard for the eye within 10 s

These lamps are in Risk Group 2 (Moderate-Risk).

4. Risk Group 3 (High-Risk)

The philosophical basis for this classification is that the lamp may pose a hazard even for momentary or brief exposure. Lamps which exeeds the limits for Risk Group 2 (Moderate-Risk) are in Risk Group 3 (High-Risk).

Pulsed lamps:

Pulsed lamp shall apply to a single pulse and to any group of pulses within 0.25 second (aversion response). The risk group determination of the pulsed lamp shall be made as Follows:

- For single pulsed lamps, a lamp whose radiant exposure is below the EL shall be classified as belonging to the Exempt Group.
- For repetitive pulsed lamps, a lamp whose radiant exposure is below the EL shall be classified using the Continuous wave lamp risk criteria; Risk Group 1, Risk Group 2.
- For repetitive pulsed lamps, a lamp whose radiant exposure exceeds Risk Group 2 shall be classified as belonging to Risk Group 3 (High Risk).

CIE: Summary of effects associated with excessive exposure to light:

Spectral Region	Eye	Skin
Ultra-violet C (180nm-280nm)	Photokeratitis	Erythema (sunburn)
Ultra-violet B (280nm-315nm)		Accelerated skin ageing process Increased pigmentation
Ultra-violet A (315nm-400nm)	Photochemical cataract	Pigment darkening Photosensitive reactions
Visible (400nm-780nm)	Photochemical and thermal retinal injury	Skin burn
Infra-red A (780nm-1400nm)	Cataract, retinal burn	
Infra-red B (1.4 μ -3.0 μ)	Aqueous flare, cataract, corneal burn	Skin burn
Infra-red C (3.0 μ -1.0mm)	Corneal burn only	

The spectral regions defined by the CIE are useful in describing biological effects.

Conclusion

- This presentation is a collaboration work between VLCC (Visible Light Communications Consortium) and ICSA (Infrared Communication Systems Association), which has been endeavoring to the standardization and promotion for the infrared communication in Japan.
- Safety issue for human is very important. This presentation mentions the safety for laser products and lamp products.
- Finally, we hope that this presentation may contribute to IEEE 802.15 WPAN for VLC standardization.

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