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Federal Department of Home Affairs FDHA
Federal Office of Public Health FOPH

Fact sheet: LED flashlights and headlights

Date:	01.08. 2021

LED flashlights and headlights generate their radiation with blue LEDs, which emit white light with the aid of a fluorescent coating on the glass bulb.

Effects on health

Intense blue light can damage the retina of the eyes. The BAG therefore commissioned a study to measure the radiation from LED flashlights and headlights so that its effects could be assessed.

The amount of blue light emitted by light sources should not exceed a certain limit to ensure that the eyes are not injured. This limit depends on the intensity of the blue light and the time for which the retina of the eye is exposed. A distinction is made between the following risk groups:

- Devices belonging to the "free" group do not exceed the threshold for injury, even when used for hours; they are safe for everyone, including children.
- Devices in risk groups 1 and 2 comply with the limit and are not dangerous as long as the eyes are only exposed for a short time.
- Devices in risk group 3 endanger the retina even after a very short exposure time (in the range of tenths of a second).

The study commissioned by the FOPH showed that if a person looked directly into the light beam, the LED flashlights that were examined could be classified as belonging to the free group or risk groups 1 or 2, depending on the model. The LED headlights were classified as belonging to the free group or risk group 1, depending on the model. The study found no LED flashlights or headlights that were classified as risk group 3.

LED flashlights and LED headlights require expert knowledge in order to avoid health risks:

- The light from LED flashlights can be very bright, depending on the particular model. You should never look directly into the light beam of an LED flashlight when it's close to you. With standard LED flashlights, the risk of eye damage is low at distances of five metres or more.
- Never aim the beam of an LED flashlight at the eyes of another person or animal.
- You shouldn't allow small children to play with LED flashlights. Teach older children how to use LED flashlights safely.
- Never look directly into the light beam of an LED headlight. If possible, position headlights so that people cannot look directly into the beam from close up.

Federal Office of Public Health FOPH
Schwarzenburgstrasse 157, CH-3003 Bern

Comprehensive information

1 Construction and beam characteristics

LED flashlights consist of a power supply with batteries or accumulators, a single LED or an LED matrix that consists of several LEDs and a reflector that bundles the beam of the LED. The reflector may be built into the LED or surround the LED as a separate component. Depending on the design of the reflector, a flashlight emits a beam with a fixed width or an adjustable width.

LED headlights consist of a power supply with batteries, accumulators or a mains connection, an LED matrix that consists of several LEDs, and optics that focus the beam of the LED to a greater or lesser extent.

2 Health impact

2.1 Visible light

Visible light that reaches the eye falls more or less unhindered on the retina, depending on age. If the light is too strong, the retina, other tissues and the photoreceptor cells can be injured. This results in thermal and photochemical processes that severely and irreversibly damage the eye and can lead to partial loss of vision or even blindness. Blue light that is too intense is a risk for the general population. Photochemical damage can also result from the reaction of blue light with substances stored in the eye (such as lipofuscin), which are deposited in the eye with increasing age (Behar-Cohen et al. 2011).

2.1.1 Limit values and standardisation for blue light hazard

In order to prevent acute risks from visible and infrared radiation, the International Commission on Non-Ionizing Radiation Protection has recommended limit values (ICNIRP 2013) that include the dangers of blue light radiation. The safety limit for blue light hazard restricts the amount of blue light radiation falling on the eye and is intended to prevent damage to the retina. This safety limit is based on the quantity of radiation at which visible damage to the retina has already occurred in 50% of sampled eyes. This limit value has the properties of a dose, i.e. the product of the radiation times the irradiation time. So to avoid injury to the retina, if the intensity of the radiation falling on it is high, the duration must be short (or if the duration is long, the intensity must be low). Two populations are distinguished with regard to the limit value for blue light hazard. 1) People with normal eyes and intact lenses and 2) people who are very sensitive to blue light, e.g. children (who have very clear lenses) or people with clear artificial lenses or no lenses at all as a result of cataract surgery.

The European standard for lamps and lamp systems can be used to assess light sources such as flashlights and headlights, and implements the limit value for blue light hazard with various risk groups (table 1). The risk groups differ in the duration for which a light source can shine on the retina without exceeding the limit value. The standard differentiates between low-intensity light sources that pose no risk even when used for an unlimited period of time, and high-intensity light sources that are only harmless for very short periods of use. These groups are defined as follows:

Risk group of lamp	Duration of eye exposure at which blue light hazard level is reached	Designation of lamp's risk group	Cautions/warnings
Free group	More than 10,000 seconds	Not required	Not required
Risk group 1	Between 100 and 10,000 seconds	Not required	Not required
Risk Group 2	Between 0.25 and 100 seconds	Required	Caution required
Risk group	Less than 0.25 seconds	Required	Warning notices required

Table 1 Risk groups

The classification of risk groups regarding the hazards of blue light sources is relatively broad, as the range of permissible exposure times within a risk group is quite broad. The exposure time of the retina at which the limit value is exceeded is a more meaningful measure of the safety of a light source.

According to the recommendations of the International Electrotechnical Commission (IEC), light sources belonging to risk groups 2 and 3 should be labelled with their risk group and with a caution or warning notice on the packaging or the product information (package insert).

2.1.2 Blue light hazard from LED flashlights and LED headlights

A study carried out by METAS (Swiss Institute of Metrology) on behalf of the BAG examined the blue light hazard due to LED flashlights and LED headlights.

LED flashlights

The study examined three LED flashlights with adjustable beam width (focused or non-focused) and two LED flashlights with fixed beam (focused beam). The results show that, depending on the model, they can be classified to the free group as well as to risk groups 1 or 2 at a distance of at least one metre (table 2). This also applies to flashlights with adjustable beam width, regardless of whether their beam is set as focused or non-focused. This means that even a very brief look into the beam of a hand-held LED flashlight can endanger your eyes. Both normal and sensitive eyes are at risk. People should therefore never point LED flashlights at themselves or at other people in their immediate vicinity. LED flashlights that are not labelled as children's toys should not be accessible to small children. At a distance of five metres, all flashlights are in the free group and do not endanger the eyes.

Distance from source	Value range for 5 different models of LED flashlights							
	Maximum exposure times in seconds				Risk group			
	Normal eyes		Sensitive eyes		Normal eyes		Sensitive eyes	
	Focused beam	Non-focused beam	Focused beam	Non-focused beam	Focused beam	Non-focused beam	Focused beam	Non-focused beam
30 cm	24 to 1062	21 to 105	22 to 1005	20 to 99	RG2, free group	RG2, RG1	RG2, free group	RG2, RG1
60 cm	24 to >10,000	44 to >10,000	23 to >10,000	42 to >10,000	RG2, free group	RG2, free group	RG2, free group	RG2, RG1, free group
1 m	25 to >10,000	250 to >10,000	24 to >10,000	240 to >10,000	RG2, free group	Free group	RG2, free group	Free group
5 m	>10,000	>10,000	>10,000	>10,000	Free group	Free group	Free group	Free group
10 m	>10,000	>10,000	>10,000	>10,000	Free group	Free group	Free group	Free group
15 m	>10,000	>10,000	>10,000	>10,000	Free group	Free group	Free group	Free group
20 m	>10,000	>10,000	>10,000	>10,000	Free group	Free group	Free group	Free group

Table 2 Maximum exposure times and risk groups for flashlights (normal and sensitive eyes). Measurements for five flashlights, three with adjustable beam width (non-focused and focused beam) and two with fixed beam width (focused beam)

LED headlights

Distance from source	**Range of values for two models of LED headlights**			
	Maximum exposure times in seconds			
	Normal eyes	**Sensitive eyes**	**Normal Eyes**	**Sensitive Eyes**
30 cm	461; 874	430; 830	RG1	RG1
60 cm	662; 1905	621; 1734	RG1	RG1
1 m	>10,000	>10,000	Free group	Free group
5 m	>10,000	>10,000	Free group	Free group
10 m	>10,000	>10,000	Free group	Free group
15 m	>10,000	>10,000	Free group	Free group
20 m	>10,000	>10,000	Free group	Free group

Table 3 Maximum exposure times and risk groups for flashlights (normal and sensitive eyes). Measurements for two headlights

The results of two measured LED headlights show that they can be classified as risk group 1 up to a distance of at least 60 cm (table 3). This means that looking into the beam of an LED headlight for several minutes can endanger your eyes. Both normal and sensitive eyes are at risk.

The blue light hazard of LED headlights at short distances cannot be comprehensively assessed with

measurements of only two products. LED headlights should therefore be operated in such a way that they are not continuously directed at people from a short distance.

2.1.3 Health assessment

The blue light component of the LED flashlights and LED headlights that were measured can injure the eyes (retinal damage) if people look directly into the light beam at short distances.

2.2 Flicker

The brightness of LED flashlights and LED headlights can vary over time, depending on the product. These fluctuations are referred to as "flicker" if people perceive that the light source shines unsteadily or varies rapidly in brightness. The temporal fluctuations in brightness (flicker) depend on the technology and quality of the power supply that provides these devices with energy. Flicker occurs in particular with power supplies whose brightness is adjusted by pulse width modulation (PWM power supplies). PWM works by switching (pulsing) DC current on and off. Varying the duration of the pulses controls the amount of current that flows to a device such as an LED. Since LEDs have much less afterglow than other light sources, the intensity of the light emitted by LEDs follows the current strength more closely than is the case with other light sources.

2.2.1 Effects of flicker on humans

Most people can detect flicker up to a frequency of 30 to 60 Hertz, but not at frequencies of 100 Hertz and higher. The retina can actually detect flicker up to 500 Hertz, but it is not perceived consciously at such high frequencies.

Very little is known about the health effects of flicker, based mainly on studies with fluorescent tubes and conventional ballast. Flicker can have immediate as well as long-term health effects. Direct effects particularly affect people who suffer from photosensitive epilepsy. They are at risk if the flicker frequency is between 3 and 70 Hertz. Prolonged flicker phenomena can lead to headaches, migraines, eye pain, impaired vision, distraction or impaired performance (Wilkins et al. 2010; Karanovic et al. 2011; Shepherd 2010).

2.2.2 Limit values

There are currently no binding limit values for flicker. The flicker properties of a light source are given as “percent flicker” or as a flicker index (Poplawski und Miller 2013). A percentage value of 0 means that a light source shines continuously and has no flicker, while a percentage value of 100 means that the intensity of the light changes periodically between the maximum and minimum (dark) amplitude.

2.2.3 Intensity of flicker

A study carried out by METAS on behalf of the BAG shows that both LED flashlights and LED headlights can flicker (table 4).

Bulbs from Device types	% Flicker: device with lowest value	% Flicker: device with highest value
LED flashlight	0	46
LED headlights	0	99

Table 4 Flicker properties of LED flashlights and LED headlights.

2.2.4 Health assessment

Whether flicker from LEDs is a health risk cannot be conclusively assessed at this (SCENIHR 2018) stage. It is therefore advisable to use flicker-free LED headlights whenever possible when using headlights.

3 Legal regulation and standardisation

Flashlights and headlights are classified as 'low-voltage products', and must therefore meet the requirements of the Ordinance on electrical low-voltage equipment (NEV SR 734.26). Low-voltage products may not endanger people or property and may only be placed on the market if they meet the basic requirements for safety and health protection of the European directive. The basic requirements are specified in the European standards. The permissible optical radiation is defined in the European standard EN SN 62471: 2008 and is based on the limit value recommendations of the International Commission on Non-Ionizing Radiation Protection in relation to non-coherent visible and infrared radiation (ICNIRP 2013). Manufacturers are responsible for ensuring that their devices conform with these criteria.

4 References

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