Internet Document Explanatory Leaflet Fact Sheet Laser Pointers

1 Summary information

A laser pointer is a hand-held laser, with which a person can project points, lines or other visual patterns.

Laser pointers, whose radiation exceeds a certain strength, may cause serious eye damage. Their radiation is highly focused and only slightly broadens out with increasing distance. At short distances from a laser pointer it is therefore possible for a great part of the laser beam to penetrate through the pupil into the eye. The eye further focuses this beam in order to focus it on the retina. This results in zones in the area of the retina which are exposed to extremely high radiant energy, such that burns, holes in the retina or bleeding may occur. Such injuries diminish the acuity of persons to such an extent that they can only roughly discern a hand moved in front of their face. Although healing prospects are possible, there is a great risk of permanent damage to the eye. If the focused laser beam impinges on the optic nerve then in the worst case this can even cause permanent blindness.

Laser pointers are classified into various danger classes. Only the lowest class 1 is absolutely safe. With class 2, eye damage is possible if a person does not reflexively avert their gaze within a quarter of a second or close their exposed eye. Consequently, children, who are attracted to light sources, are particularly endangered as they may stare into the laser beam for protracted periods. With laser pointers in the higher laser classes 3R, 3B and 4, eye injury is probable or certain. This is further aggravated by the fact that often laser pointers emit more powerful beams than may be presumed from their class.

Furthermore, the beams from laser pointers may dazzle the eyes. This may lead to irritations, temporary loss of vision as well as long lasting afterimages. The latter lead, among other things, to people not being able to correctly identify colours or to see them at all. When people are dazzled, they may be in danger as they no longer visually perceive their environment correctly.

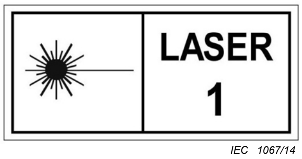
New legal regulations for laser pointers:

Parliament recognises these health risks and has adopted the Federal Act on Protection against Non-Ionising Radiation and Sound (NIRSA), which provides for a prohibition of dangerous laser pointers. The related Ordinance to the Federal Act on Protection against Non-Ionising Radiation and Sound (O-NIRSA) was adopted by the Federal Council on 27 February 2019.

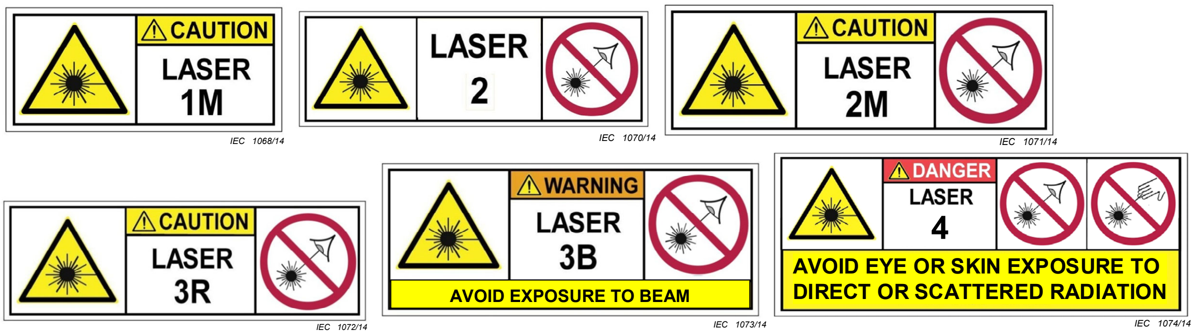
Weitere Informationen:
Bundesamt für Gesundheit BAG
Abteilung Strahlenschutz, Sektion NIS/DOS
Schwarzenburgstrasse 157, CH-3003 Bern
www.bag.admin.ch

Based on the new legislation, dangerous laser pointers are banned in Switzerland as of 1 June 2019; safe laser pointers are still allowed. The most important points of the new legislation which must be complied with are presented below:

How can I tell if my laser pointer is safe and permitted?
The laser pointer is safe if it carries the marking shown below.



How can I tell if my laser pointer is dangerous and banned?
The laser pointer has markings that infer that the laser class is 1M, 2, 2M, 3R, 3B or 4. The markings may be in German, French or English:



- The laser has other markings such as laser class 3A, IIIA, 1C.
- The laser has no or no identifiable marking to a laser class.

What exactly does the ban apply to?
- Owning a dangerous laser pointer.
- Importing dangerous laser pointers into Switzerland.
- Transiting dangerous laser pointers through Switzerland, i.e. importing and subsequently exporting them.
- Issuing dangerous laser pointers, i.e. any offering that involves distributing, issuing or using a laser pointer, whether free of charge or in return for payment.

How do I dispose of banned laser pointers?
- Dispose of them as electrical waste. You can find your nearest disposal point with the aid of the https://recycling-map.ch/en/ website, for example, or using the "Recycling Map" smartphone app that is available for iOS and Android.
- Remove the batteries first and dispose of them at a battery collection point. If it is impossible to remove the batteries from the pointer, you can dispose of the entire device at the battery collection point.

Where can I get more information?
You can find further information on laser pointers of the Federal Office of Public Health's website at https://www.bag.admin.ch/bag/de/home/gesund-leben/umwelt-und-gesundheit/strahlung-radioaktivitaet-schall/elektromagnetische-felder-emf-uv-laser-licht/laser-und-lasershows.html

Further FOPH recommendations on laser pointers

- For lectures, preferably use the electronic laser pointer function incorporated in the presentation programme software
- Use a software supported, hand-controlled laser pointer system that generates no laser radiation. These virtual laser pointers are available in specialist shops
- Class 1 laser pointers are suitable for use in meeting rooms and class rooms

General recommendations when dealing with accidents with laser beams

Immediately get medical assistance if you have been hit with a laser beam in the eye or on the skin as symptoms may develop or you are not sure of the need for medical treatment

2 Detailed information

2.1

Laser pointers are products that, as a result of their size and weight, can be held in the hand or be carried about, and which emit a laser beam for the purposes of pointing, entertainment or repulsion:

- Laser pointers for pointing purposes are products that are marketed for actually highlighting something. This category also includes similarly designed and operational products with integrated laser pointers such as key rings, remote controls or pocket knives.
- Laser pointers for entertainment purposes are products that are marketed as show lasers, as toys, as toys for animals, for hobbies or for other similar purposes. This category also includes laser devices with laser pointer functions which are produced, assembled or self-made from semi-finished products.
- Laser pointers for defence which are marketed as repellents against animals or people as well as for personal protection equipment.

The core element of a laser pointer is the laser diode that generates the laser beam. The beam is aligned optically parallel in a collimator and then exits the housing. With powerful laser pointers of classes 3R, 3B and 4, the location of the beam exit must be marked in order to avoid health risks.

The beam from a laser pointer is monochromatic and consists of a single colour that depends on the semiconductor material of the diode. Depending on its composition the beam is visible or must first be rendered visible. The latter principle is mainly the case for laser pointers with a green or blue beam colour. They generate invisible infrared laser radiation that is subsequently converted into visible radiation by a frequency doubler. In order to obviate health risks and fire risks with laser pointers of this type, infrared filters should be used to prevent the infrared laser beam from exiting the laser pointer. However, in relatively poor quality laser pointers, this protection is often inadequate (Galang et al. 2010; Hadler et al. 2013; Khedr and Khedr 2014; Hanson et al. 2016). Consequently, one should generally avoid looking directly into the beam of any laser pointer.

The beam from laser pointers is highly focused and has a high intensity. For a laser pointer, the variance from the focusing or the "divergence" is typically circa one millirad and corresponds to a broadening of the beam diameter by one metre at a distance of 1000 metres (Dickmann 2014; Reidenbach et al. 2014). The divergence can be reduced with additional lenses, such that the beam exhibits high energy densities even at great distances. The energy distribution is not constant across the cross-section and depends on the laser pointer manufacturer.

2.2 Health Risks

2.2.1 Risks and limit values

Health risks from high-power laser beams depend on the exposure time and the wavelength (or colour) of the beam:

- In the ultraviolet range up to a wavelength of 400 nanometres [nm], the beam cannot pass through the ocular media, such that the cornea may be thermally damaged.

- In the visible range (wavelengths between 400 and 780 nm), the beam can penetrate the ocular media to the retina and be absorbed there. The resulting increase in temperature may thermally damage the retinal area. The beam also produces aggressive oxygen molecules inside the eye which may lead to photochemical damage in the eye and to the retina.
- In the near infrared range (wavelengths between 780 and 1400 nm), the beam can advance to some extent through the ocular media to the retina and be absorbed there. The resulting increase in temperature may thermally damage the retinal area.
- In the middle and far infrared range (wavelengths greater than 1400 nm), the beam cannot pass through the ocular medium because the aqueous cell components of the eye absorb the beam. Consequently, thermal or thermomechanical damage occurs mainly to the cornea and also partly in the ocular lens.

The incidence of the visible and near infrared components of the beam on to the retina is also intensified by the cornea and the ocular lens, which focus the radiation on to the retina. This leads to radiation intensities on the retina which are up to 100 000 times greater than the radiation intensity of the original laser beam. Accordingly, the retina represents the body tissue that is most susceptible to be damaged by laser radiation.

With a view to prevent damage to health, the *International Commission on Non-Ionizing Radiation Protection* (ICNIRP) published guidelines for limit values of laser beams. The limit values contain safety factors of 2 for the cornea and between 2 and 10 for the retina. The safety factors that are minor in comparison to other dangers require that manufacturers and distributors correctly label laser pointers and that users use laser pointers safely and respect the manufacturers' guidelines.

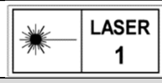
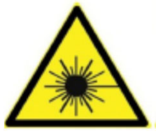
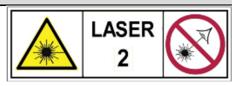
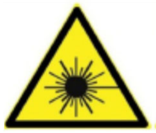
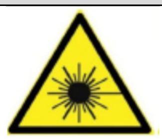
Whether the radiation limit values also prevent possible long-term effects is unclear according to the ICNIRP, based on present knowledge.

2.2.2 Laser Classes / maximum permissible exposure MPE

In practice, the radiation limit values are converted into laser classes that have to be assigned by the manufacturers of the lasers or laser pointers. The laser classes limit either the laser power, such that the laser is only capable of emitting the "maximum permissible exposure MPE" that corresponds to the limit value of the ICNIRP. If this is not possible and the radiation limitation itself offers no health protection, then the laser class instructs the user to take adequate safety measures that ensure health protection.

The laser classes are stipulated in the basic standard for lasers and have to be visibly stated on a laser pointer. They consist of an explanatory label, and for dangerous lasers also a triangular, yellow warning label with a laser beam symbol. Explanatory labels, warning labels, alternative labels and (not to be installed on the laser pointer) explanations on health hazards of the individual classes are presented in Table 1.

Table 1: Laser Classes – Legend and Measures

Class	Warning Label	Explanatory Label for Measures	Alternative wording
	Health Hazard		
1	not available	CLASS 1 LASER	
	• Eye-safe laser, no hazard to health even for prolonged viewing into the beam, • The maximum permissible exposure MPE is in any event not to be exceeded.		
1M		LASER RADIATION DO NOT EXPOSE USERS OF TELESCOPIC OPTICS CLASS 1M LASER PRODUCT	
	• A diverging or broadened beam that is eye-safe to the naked eye and does not represent a health hazard even with prolonged viewing into the beam. • The beam can be focused dangerously by optical instruments such as binoculars, opera glasses, levelling instruments, theodolites etc. and may lead to exposures that correspond to those of laser class 3R or 3B. People must be specifically warned of these risks.		
2		LASER RADIATION DO NOT STARE INTO BEAM CLASS 2M LASER PRODUCT	
	• For exposure times up to a ¼ second corresponds to a class 1 laser; • With the naked eye no health hazard, insofar as a person has the reflex action to close their eye within a ¼ second or can turn away; • It is dangerous to deliberately stare into the beam, such that the maximum permissible exposure MPE is exceeded.		
2M		LASER RADIATION DO NOT STARE INTO BEAM OR EXPOSE USERS OF TELESCOPIC OPTICS CLASS 2M LASER PRODUCT	
	• Diverging or broadened beam that presents no health hazard for the naked eye, insofar as a person has the reflex action to close their eye within a ¼ second or can turn away; • It is dangerous to deliberately stare into the beam, such that the maximum permissible exposure MPE is exceeded; • The beam can be focused dangerously by optical instruments such as binoculars, opera glasses, levelling instruments, theodolites etc. and may lead to exposures that correspond to those of laser class 3R or 3B. Users must ensure that they do not expose users of telescopic optics.		
3R		LASER RADIATION AVOID DIRECT EYE EXPOSURE CLASS 3R LASER PRODUCT	
	• Limited health hazard; • Maximum permissible exposure MPE exceeded; • Wear eye protection • Use only when justified; • Only for qualified and trained personnel; • Lasers not in use to be secured against unauthorised access.		

3B		WARNING - LASER RADIATION AVOID EXPOSURE TO THE BEAM CLASS 3B LASER PRODUCT	
	• Certain health hazard for eyes and possibly for skin; • Maximum permissible exposure MPE exceeded; • Use only in a delimited and monitored laser area; • Take security precautions, such that no-one is inadmissibly exposed; • Control access to the laser area; • Fire hazard possible if the diameter of the beam is small or the beam is focused.		
4		DANGER – LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DI-RECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT	
	• Certain health hazard for eyes and skin • Maximum permissible exposure MPE exceeded. • Use only in a delimited and monitored laser area; • Take security precautions, such that no-one is inadmissibly exposed; • Control access to the laser area. • Fire hazard if the diameter of the beam is small or the beam is focused		

Notes:

- It is possible that Class 1M and 2M lasers may have higher power levels than classes 1 and 2. As the beam from such lasers is broadened out, then as of a certain distance only a part of the beam can be incident on the eye. This portion of radiation must not exceed the specifications for classes 1 and 2; the determining factors here are an aperture (pupil) of 7 mm diameter as well as the minimum distances given in the basic standard for lasers.
- For class 2 lasers the safety considerations of the basic standard for lasers are based on the “corneal reflex” and to reactions to turn away, which trigger the eye to close or to turn away within a quarter of a second after the radiation enters the eye. However, volunteer studies show that less than one fifth of the volunteers have the corneal reflex.
- The American laser class 3a or IIIa corresponds to the European laser class 3R. Lasers that are put on the market in Switzerland have to be labelled with the European Classes.

2.2.3 Outputs

The permitted outputs for lasers are presented in Table 2 for each laser class. They are based on the basic laser standard.

Table 2: Permitted outputs for the laser classes

Class	wavelength [nm]	Underlying exposure times [sec]	Permitted output [mW]
1	400-450	>100	0,039
	450-500	>100	0,039-0,39[1]
	500-700	>100	0,39
2	400-700	< 0.25	analogous to class 1
	400-700	≥ 0.25	1
3R	400-700	≥ 0.25	5
3B	400-700	≥ 0.25	≤500
4	400-700	≥ 0.25	>500

Numerous studies have determined the effective outputs of laser pointers and compared them with their stated laser class. The results show that for a significant proportion of laser pointers, the laser class and the appropriate measures to be taken were not correctly stated. This is also aggravated in that many of these incorrectly classified laser pointers radiate more strongly than stated on the product. Consequently, in general, persons should not look directly into the beam of any laser pointer.

2.2.4 Accidents

The number of accidents involving laser pointers in Switzerland is difficult to estimate. In a representative survey of about 2000 people carried out by the research institute gfs in 2013, eleven per cent of those surveyed stated that they had been dazzled at least once by a laser pointer. In particular people aged below 26 appears to be particularly affected, as every fifth person in this age group had already been dazzled. During the incident, more than one tenth of the dazzled persons were driving a means of transport. An extrapolated half a per cent of the Swiss population received medical treatment as a result of being dazzled. Furthermore, twice as many people who possess a laser pointer were dazzled in comparison to people who did not own a laser pointer.

Scientific studies on the damage to health caused by health hazards relate exclusively to individual persons; there are no epidemiological studies on the topic. The accidents were caused by laser pointers that were indicated as class 2, 3R (or as American class 3a), 3B or 4 or which belong to these classes based on their output. Typical dangerous situations were looking directly into the beam as well as looking into a beam reflected from shiny or reflective surfaces. The accidents were knowingly or unknowingly caused by the victims themselves or by third parties. The latter situation occurs particularly with children or adolescents who knowingly carry out a dare or laser experiments and thereby harm their own eyes. Accidents that occurred with laser class 3R show that the corneal reflex mechanism and turning away do not afford adequate protection even with moderately powered lasers.

A review of the studies that concern accidents with laser pointers may be found under "Documents". It is often the case that laser pointer accidents lead to the injured being strongly light sensitive, have blurred vision or see spots or scotoma in their field of view. The causes of these symptoms are burns to the macula, the fovea and the retinal pigment epithelium, retinal holes or bleeding inside the eye.

[1] between 450 nm and 500 nm the value increases exponentially from 0.039 mW to 0.39 mW

2.3 Dazzling

2.3.1 Mechanisms

The dazzling effects of laser pointers endanger persons who work in air travel, in traffic, in the police force and in security services or who participate in sporting events. These people may temporarily lose their vision by looking at the laser beam. This results in the following effects:

- Dazzling leads to irritations that disappear immediately when the dazzling laser beam stops (similar to the dazzling occasioned by an oncoming vehicle when driving in the twilight)
- Flash blindness leads to a vision loss that can last seconds, during which the dazzled persons can no longer perceive their environment
- Afterimages are sensory impressions, in which the dazzling laser beam persists on the retina for several seconds or minutes and distorts the black-white and colour vision, such that people can no longer correctly perceive their environment (similar to the afterimages that result when looking directly - and dangerously - at the sun)

The dazzling effects depend on the laser beam energy that impinges on the eye. Due to their focused beam, laser pointers therefore differ fundamentally from other light sources, such as for example pocket lamps that exhibit a significantly broader beam angle, with the result that the beam energy is distributed over a greater spatial area and only a fraction of the radiation can penetrate the eye.

In addition to the actual dazzle effect, in which a laser beam enters the eye, laser pointers may give rise to scattering effects on dirty, wet or scratched windscreens and light up a cockpit, for example (Figure 1).

Figure 1: Dazzling effect with a laser pointer on the cockpit of a helicopter

Besides such physiological effects, laser pointers also cause psychological effects. Such shock situations mainly occur when in clear atmospheric conditions a person suddenly perceives a laser beam as it meets the eye or a windscreen.

Green laser beams produce the strongest dazzling effect, as this wavelength is particularly well perceived by the human eye. Laser pointers of other colours such as red and blue are less dazzling. Also, strong dazzling effects occur during twilight or the night because the eyes are then attuned to the limited light conditions and the pupils have a large diameter.

2.3.2 Extent of dazzling

Pilots have reported around 500 laser dazzlements in Switzerland in the years 2010 to 2017. The competent authorities have classified around 100 of these cases, in which the crews were adversely affected by laser dazzlement, as serious. However, the competent authorities assume a considerably higher number of cases. The dazzlements notified in the years 2013-2020 are presented in Table 4.

Table 4: The number of reported dazzlements in Swiss airspace

Year	Dazzlements of aircraft crews	Dazzlements of helicopter crews
2013	136	14
2014	111	9
2015	108	15
2016	79	10
2017	92	11
2018	77	5
2019	68	5
2020	22	9

Numbers for other endangered professional groups have not been determined. Nonetheless, an analysis of the situations in which attacks with laser pointers typically occur enables an assessment of the possible danger. Besides the power and colour of the laser beam, the distance between the person using the laser pointer and the dazzled person is also crucial. This distance determines the extent to which the laser beam broadens out and the proportion of the beam energy that can penetrate through the pupil into the eye. For the affected professional groups the typical distances range between less than 10 metres (police) and 300 metres (civil aircraft). Based on the findings of a German study with volunteers it was calculated that all classes of laser pointers cause dazzlement for a few seconds, thereby impairing a person's reading ability. Consequently, class 1, 1M, 2 and 2M laser pointers that due to their limited power do not cause any danger to health, also pose a danger resulting from their potential to dazzle.

2.3.3 Recommendations for limit values as regards dazzlement

No mandatory limit value exists in order to prevent dazzlement by laser pointers. An exception is the limit value recommendations of the ICAO (International Civil Aviation Organisation) which concern visible laser radiation in flight corridors, landing approaches and airports. The recommendations differentiate the following zones

- *Laser-beam free flight zone (LFFZ).* Airspace in close proximity to the airfield, in which the irradiance is limited, such that no visual disturbances of people occurs.
- *Laser-beam critical flight zone (LCFZ).* In the airspace adjacent to the LFFZ near an airfield, in which the irradiance is so limited that it can cause hardly any dazzling effect.
- *Laser-beam sensitive flight zone (LSFZ).* Airspace outside the LFFZ and LCFZ in which the irradiance is so limited that flash-blindness or afterimages are unlikely.
- *Entire airspace:* In the entire airspace the irradiance of each visible or invisible laser beam must be less than or equal to the maximum permissible exposure (MPE), unless the perpetrator has notified the emission to the competent authority and received approval.

2.4 Legal Regulations in Switzerland

2.4.1 New legal regulation as of 1 June 2019

The new law that came into force on 1 June 2019 comprehensively governs laser pointers. It consists of the "*Federal Act on Protection against Non-Ionising Radiation and Sound NIRSA*" and the Ordinance "*Ordinance on Protection against Non-Ionising Radiation and Sound O-NIRSA"* link.

The NIRSA, adopted by the National Council and Council of States on 16 June 2017, offers the possibility, in cases of a substantial risk to health, to prohibit as a last resort the import and transit, the sale and the possession of products. The focus is on dangerous laser pointers, whose irradiance significantly exceeds the limit values for eyes and skin or which, due to dazzlement, constitute a serious safety problem for specific professional groups.

The Ordinance V-NIRSA, adopted by the Federal Council on 27 February, specifies the relevant measures. Due to the problems of dazzlement it prohibits the import, the transit, the possession and the delivery of all laser pointers of classes 1M, 2, 2M, 3R, 3B, 4. The import, the transit, the possession and the delivery of laser pointers of class 1 is permitted. Due to their existing dazzling potential, these laser pointers may only be used indoors. In this way dazzlements, which mainly occur in outdoor environments, will be prevented.

3 References

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