Caution: laser beam!

Information on the safe use of laser devices

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working safely

Improper handling of lasers can cause permanent damage to your health, in particular to the eyes and skin.

This brochure provides information on the dangers and the necessary protective measures when operating laser devices.

It is primarily intended for safety officers and supervisors in companies with laser products, but it also addresses employees who use lasers and distributors of laser products. It will help you to handle lasers safely and lawfully.

Content

1 Ubiquitous but not harmless

Lasers have become an indispensable part of our modern world. They are used as versatile tools in commercial and industrial applications, be it for cutting, marking, welding, for distance measurement, in telecommunications or for various other applications. Lasers are also used in many areas in medicine or cosmetics such as in surgery, including eye surgery, for skin treatments or for hair removal. For research, lasers have long been standard equipment. And which person has never held a laser pointer in his hand, or does not own a CD, DVD or Blu-ray player?

Lasers are therefore ubiquitous. Yet lasers are not harmless toys. Even minor negligence when handling them can have a major impact on your health or that of others.

Therefore, be sure to rigorously implement the protective measures described in this brochure to ensure that lasers are handled safely, everywhere and every day.

This brochure does not claim to be exhaustive. If in doubt, the standard SN EN 60825-1:2014 «Safety of laser products – Part 1: Equipment classification and requirements» shall apply. For details on fibre-optic communication systems, you can refer to standard SN EN 60825-2:2004 «Safety of laser products - Part 2: Safety of optical fibre communication systems (OFCS)» or refer to Appendix G of this publication.

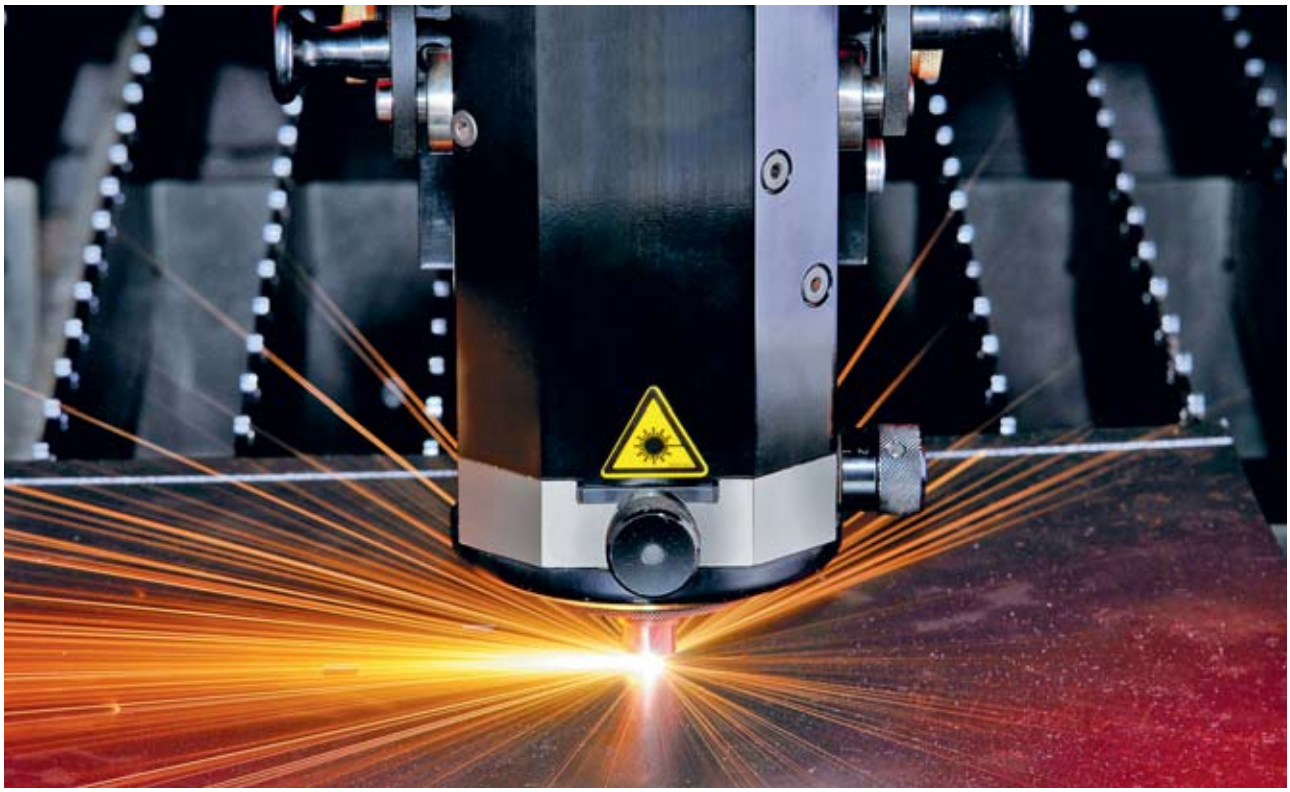


Figure 1: Lasers are not harmless toys. Even minor negligence when handling them can damage your health.

2 Why is laser radiation dangerous?

2.1 What is a laser?

The word laser is English and an acronym for «Light Amplification by Stimulated Emission of Radiation». Figure 2 illustrates how a laser works. A laser medium is excited (pumped) by an external energy source. Depending on the material of the laser medium, this begins to emit the characteristic radiation due to the excitation (e.g. green from argon ions, red from a helium-neon gas mixture or infrared from a titanium/sapphire crystal). This radiation is reflected by mirrors (resonator), amplified, and finally directed to the outside through a partially transparent mirror.

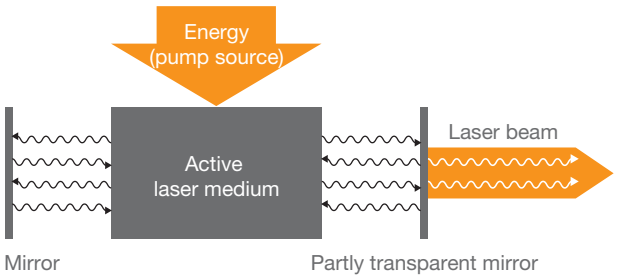


Figure 2: How a laser works

2.3 Health hazards

Exposure to a laser with only a few milliwatts of power can damage the human eye or even lead to vision loss. This not only applies to visible radiation (400 nm to 700 nm wavelengths) but also to invisible radiation (all other wavelengths). Although this radiation is not seen, it nevertheless enters the eye (unnoticed) and is focused on the retina. Since even faint reflections from a few milliwatts of output power can cause permanent retinal damage, particular caution is required here.

Laser radiation can not only injure the eyes but skin tissue as well. In the red and infrared range of the spectrum, thermal processes in particular lead to injuries in which the incident laser output is absorbed by the tissue and causes it to heat up or burn. In the case of infrared lasers, the tissue under the skin can also be damaged without this being visible on the skin surface. In the short wavelength range (blue and UV), this includes photochemical damage which occurs when light is absorbed by the molecules. A typical example of this photochemical process is sunburn.

Should the eye or skin be unexpectedly struck by a laser beam or should any irritation, redness or burns occur after any accidental radiation, seek prompt medical attention.

2.2 The difference between laser light and «normal» light sources

Most light sources (e.g. light bulbs, energy saving bulbs or LEDs) generate white light and emit it in all directions. The radiant intensity thereby rapidly decreases with increasing distance from the light source. Laser light, in contrast, is directed and travels mostly parallel. This causes the laser beam itself to expand or contract only slightly over long distances.

If the parallel incident laser light now enters the eye, the total radiation output generated in the laser will focus on a small impact point and is also focused on the retina there by the eye lens (Figure 3). Because the entire laser output is projected onto a tiny spot of the retina, very high output density results locally.

However, only a fraction of the radiant energy from a normal light source enters the eye because the light is emitted uniformly in space. In addition, the light source is displayed over a large area on the retina and not focused onto a point like a laser (Figure 3).

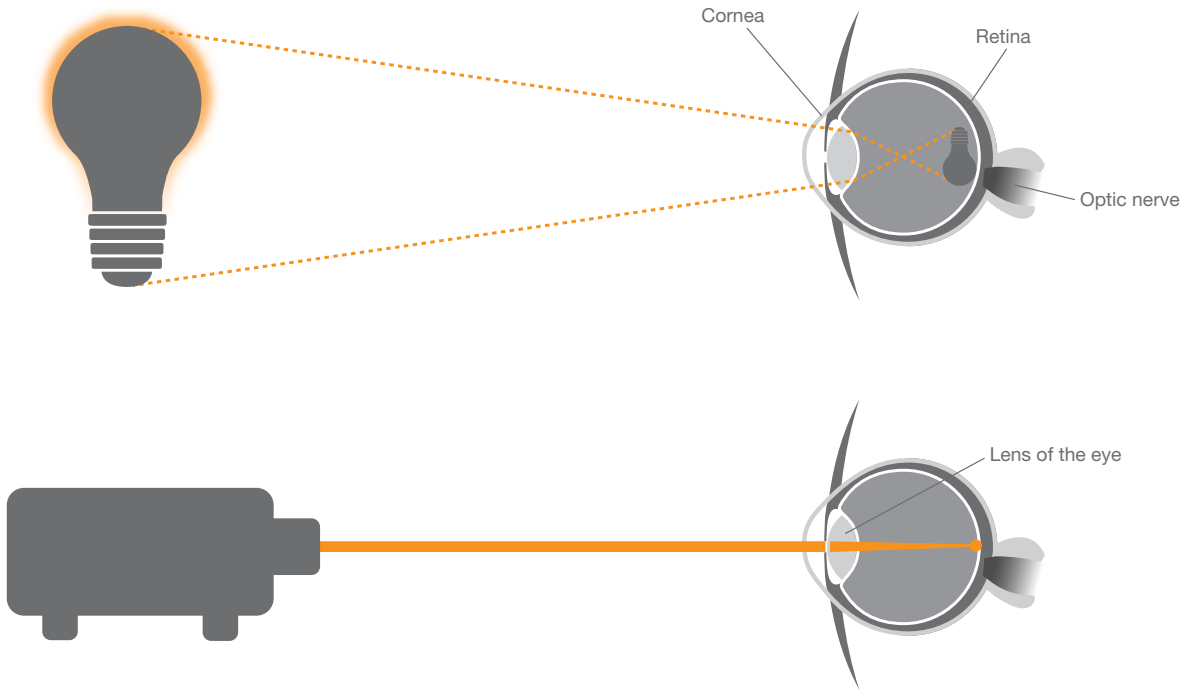


Figure 3: As an example, we compare directly staring into a common light source with 15 W output and into a red laser with a 1 mW output from one meter away. Staring at the 15 Watt light source may be uncomfortable, but certainly does not lead to an immediate loss of vision. However, damage can be caused immediately when a laser with «only» 1 mW output hits the eye directly. This is because the laser generates roughly a 35,000 times greater power density on the retina than the common light source, due to the total output being projected onto the retina by the laser.

3 Safety measures according to laser classes

Lasers can pose a potentially serious hazard. But just how dangerous is each laser? This question is answered by the various laser classes. Every laser in Switzerland must be allocated to a certain laser class as per laser safety standard[1]. The laser class describes the hazard potential of a laser from which the necessary protection measures can, in turn, be derived.

Every operator of laser devices or every employer is obliged to implement all necessary occupational health and safety measures, to document these, and to monitor their compliance periodically. The safety objectives are derived from the laser safety standard. The legal bases are the Federal Law on Accident Insurance (UVG)[2], the Ordinance on the Prevention of Accidents and Occupational Diseases (VUV)[3] as well as the EKAS directive 6508 and the Suva publication «Grenzwerte am Arbeitsplatz» (Threshold Limit Values at the Workplace)[4].

This chapter describes the different laser classes and the measures derived for them. Particular attention is given to laser classes 3B and 4 (see also Chapter 4). These require additional measures due to the increased hazard.

3.1 Class 1 laser

No danger emanates from Class 1 lasers under reasonably foreseeable operating conditions; also when using optical aids such as binoculars or microscopes. If the radiation is accessible, then it is so weak that any injury can be ruled out. Nevertheless, the straigth view to the laser beam (in the visible range) can laead to glare effects. However, Class 1 lasers also includes high-power lasers that are completely enclosed by shielding so that no dangerous radiation is emitted outside.

Safety measures: No measures are required. Class 1 lasers must be safe to handle in normal operation without instruction.

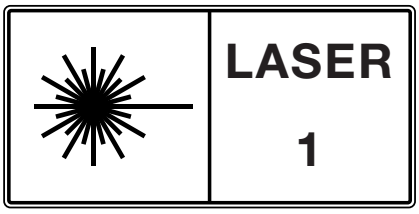


Figure 4: Labelling Class 1 lasers. Alternatively, use the labelling as in Chapter 6.2.

1 SN EN 60825-1:2014
2 see for example Art. 82 UVG
3 see for example Art. 3, 8 and 45 VUV
4 order no. 1905.d

3.2 Class 1M lasers

The beam of a Class 1M laser has a larger diameter than the pupil of the eye so that only part of the radiation can reach the retina. Class 1M lasers are harmless to the naked eye, even after long-term exposure. However, damage to the eye is possible if the beam is focused through additional optical instruments such as binoculars or microscopes (eyeglasses excluded). This way, a larger proportion of the radiation can pass through the pupil. The wavelength is limited to the 302.5 nm to 4000 nm range in this class.

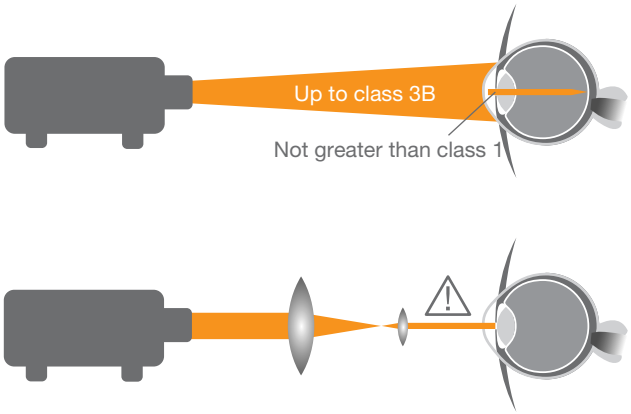


Figure 5: A Class 1M divergent beam is safe for the eye. However, focusing a Class 1M laser beam through an optical aid does pose a hazard to the eyes.

Safety measures: Do not direct the beam at other persons. Specifically warn persons who might use optical instruments (telescopes, microscopes).

Figure 6: Labelling Class 1M lasers. Alternatively, use the labelling as in Chapter 6.2.

3.3 Class 1C lasers

Class 1C lasers are used to directly treat skin or tissue during medical, therapeutic or cosmetic procedures. The emitted laser radiation can correspond to Class 3R, 3B or 4. It must be guided to the part of the body to be treated and monitored by at least one safety mechanism of the device so that the accessible radiation complies with the Class 1 requirements.

The maximum exposure of the skin and the additional necessary safety equipment depend on the specific application and are defined in other relevant standards[5].

Safety measures: Check safety equipment periodically and follow the manufacturer's safety instructions.

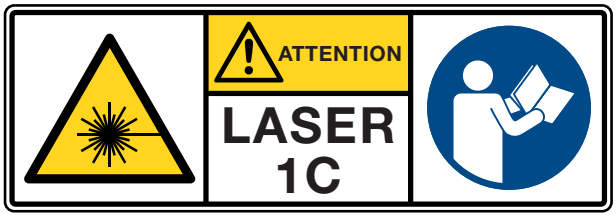


Figure 7: Labelling Class 1C lasers. Alternatively, use the labelling as in Chapter 6.2.

5 see e.g. SN EN 61508, SN EN 60601 and SN EN 60335

3.4 Class 2 laser

Class 2 lasers only emit radiation in the visible range of the spectrum (400 nm to 700 nm). No damage to the eye can be expected from a short-term exposure of less than 0.25 s. In continuous wave mode (cw), Class 2 lasers emit 1 mW at most. Nevertheless, radiation with Class 2 lasers may cause afterimages or glare effects. This can lead to temporary visual impairment, which may have serious consequences, for example, during safety-critical work on machinery, when working at heights, when driving a vehicle or for pilots.

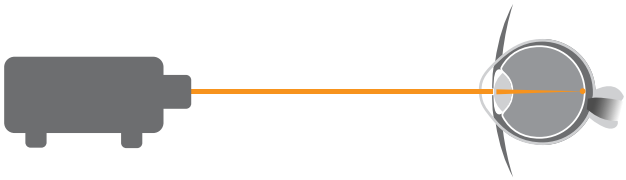


Figure 8: Class 2R lasers can be hazardous to the human eye.

Safety measures: Do not stare into the beam. Do not direct the beam at other persons. Should you still be struck by a beam, deliberately close your eyes and turn away from the light source immediately.

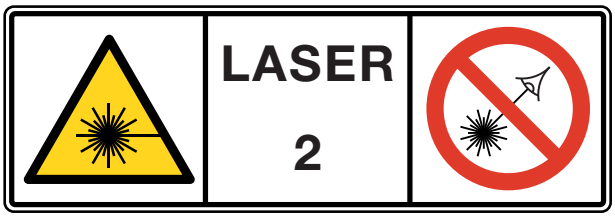


Figure 9: Labelling Class 2 lasers. Alternatively, use the labelling as in Chapter 6.2.

3.5 Class 2M lasers

The beam of a Class 2M laser has a larger diameter than the pupil of the eye so that only part of the radiation can reach the retina.
Class 2M lasers only emit radiation in the visible range of the spectrum (400 nm to 700 nm). Short-term exposures (< 0.25 s), without the use of optical instruments such as binoculars or microscopes (eyeglasses excluded), are safe.

As with Class 2, radiation may cause afterimages or glare effects. This can lead to temporary visual impairment, which may have serious consequences, for example, during safety-critical work on machinery, when working at heights, when driving a vehicle or for pilots.

Safety measures: Do not stare into the beam. Do not direct the beam at other persons. If you are hit by a laser beam, close your eyes and turn away. Specifically warn persons who might use optical instruments (telescopes, microscopes).

Figure 10: Labelling Class 2M lasers. Alternatively, use the labelling as in Chapter 6.2.

3.6 Class 3R lasers

With this laser class, radiation may not exceed more than five times the maximum permissible output for Class 1 lasers of the same wavelength. The maximum is limited to 5 mW. Class 3R lasers can damage the human eye, but the risk of injury is relatively low due to the natural aversion responses and the fact that the eye is only rarely exactly struck over prolonged periods of time.
However, glare can also lead to temporary visual impairment in the form of afterimages, which may have serious consequences, for example, during safety-critical work on equipment, when working at heights, when driving a vehicle or for pilots.

Safety measures: Only use qualified and trained personnel. The open beam must not pass at eye level (either when sitting or standing), otherwise the application range must be shut off. The laser must be protected against unauthorized access.

Figure 11: Labelling Class 3R lasers. Alternatively, use the labelling as in Chapter 6.2.

3.7 Class 3B laser and 4

Staring into Class 3B lasers is dangerous and may cause eye damage (even from brief, accidental exposure). Gazing at diffuse reflections is normally not harmful to the eye. Direct exposure to the laser can also damage the skin or inflame combustible materials. Class 3B lasers emit at most 0.5 watts in continuous wave mode.

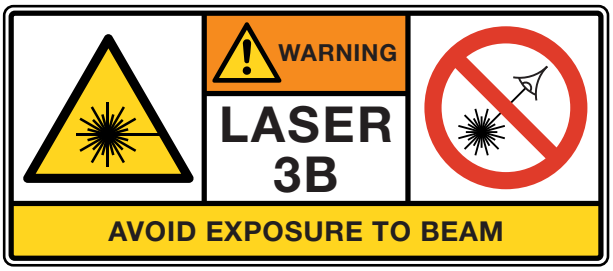


Figure 12: Labelling Class 3B lasers. Alternatively, use the labelling as in Chapter 6.2.

Direct irradiation as well as reflections endanger the eye and skin to a great extent. Class 4 lasers also often represent a fire hazard. All lasers that cannot be allocated to a lower class are assigned to Class 4. There is no upper output power restriction for this class.

Figure 13: Labelling Class 4 lasers. Alternatively, use the labelling as in Chapter 6.2.

Safety measures for Class 3B and 4 lasers:
Class 3B and 4 lasers may only be operated (completely enclosed as a Class 1 laser) or, if not possible otherwise, in a defined and monitored laser area. The operator must ensure that no one can be unduly irradiated. In this regard, he is obliged to take the necessary safety precautions and train or instruct the employees accordingly. Please refer to Chapter 4 for more details.

4 Special requirements for Class 3B and 4 lasers

Class 3B and 4 lasers are completely shielded and enclosed by a housing so that no radiation is emitted to the outside. In this case, the laser with closed housing corresponds to Class 1. All safety-related shielding is to be monitored with safety switches or may be removable only with the help of tools. If complete shielding is not possible due to technical or other reasons, then various other safety precautions are required, as listed here.

4.1 The laser safety officer

Figure 14: Anyone who operates Class 3B and 4 lasers requires a laser safety officer.

According to EKAS directive 6508, Class 3B and 4 lasers represent a special hazard. Businesses that employ these kinds of lasers are therefore obliged to develop a safety system that is adapted to the specific needs. To do this, you can either call in external occupational safety specialists or acquire the necessary occupational safety knowledge yourself. You are then also obliged to commission a laser safety officer, whose duties are specified by management.

4.1.1 Training

A laser safety officer must have the necessary knowledge in order to fulfil his tasks. The way in which he must acquire this knowledge is not legally stipulated. He may do so, for example, from a training course, the manufacturer's instructions and/or from independent learning.

The **duties and necessary expertise** of a laser safety officer include at least the following points:

- Knowing the potential hazard of the laser (according to classification) and the effect of laser radiation on the body (skin and eyes) and taking the appropriate protective measures.
- Defining safety regulations, creating work instructions and instructing employees.
- Obtaining the proper personal protective equipment and instructing employees on its use.
- Knowing the technical protective equipment against laser radiation, installing it if necessary and checking its functionality periodically.
- Knowing other hazards from laser radiation (e.g. fire, release of harmful substances, high voltage, etc.) and taking the appropriate measures.
- Knowing the manufacturer's operating instructions and ensuring compliance with the safety regulations described therein.
- Defining how to react in case of a malfunction and instructing employees periodically.

4.1.2 Safety concept

Companies that use Class 3B or 4 lasers must, as part of their general duties, identify the hazards to the safety and health of their employees and take the necessary protective measures and make arrangements in accordance with standard engineering practice. The laser safety officer creates this safety concept. It is advisable to keep a written record of the measures adopted.

4.1.3 Instructing employees

The laser safety officer must inform those persons who work with Class 3B and 4 lasers about the hazards and instruct them on their correct operation before they commence any tasks. It is advisable to confirm that the instruction was carried out by countersigning it and to post important work instructions in abbreviated form in the workplace.

4.2 Laser equipment in manufacturing areas

Laser equipment that is used as machines for industrial application in (open) manufacturing areas must not cause any hazards from accessible laser radiation either in normal or in special operation. This is achieved by a completely shielded protective housing. When the housing is opened, the hazardous beam must be interrupted immediately.
If it is necessary to observe the processing process of the laser, a window with a laser safety filter can ensure the necessary eye protection.
The demands made on the protective enclosure and safety interlocks are described in the laser safety standard[6] or other standards are referred to therein[7]. Shielding that can be removed without tools must be connected to the safety monitoring system.

If complete all-round protection cannot be implemented due to process-related reasons and the laser is not located in a laser controlled area, then a risk analysis must be performed. Protective measures must be taken based on this. Among other things, the safety margin[8] at which a foreseeable risk can be ruled out in this case must be negligible. Never stare directly at the processing point and avoid the emission of «single reflections» in all cases.

If the laser machine cannot be shielded or encapsulated at all, it must be operated in a structurally enclosed laser area with controlled access.

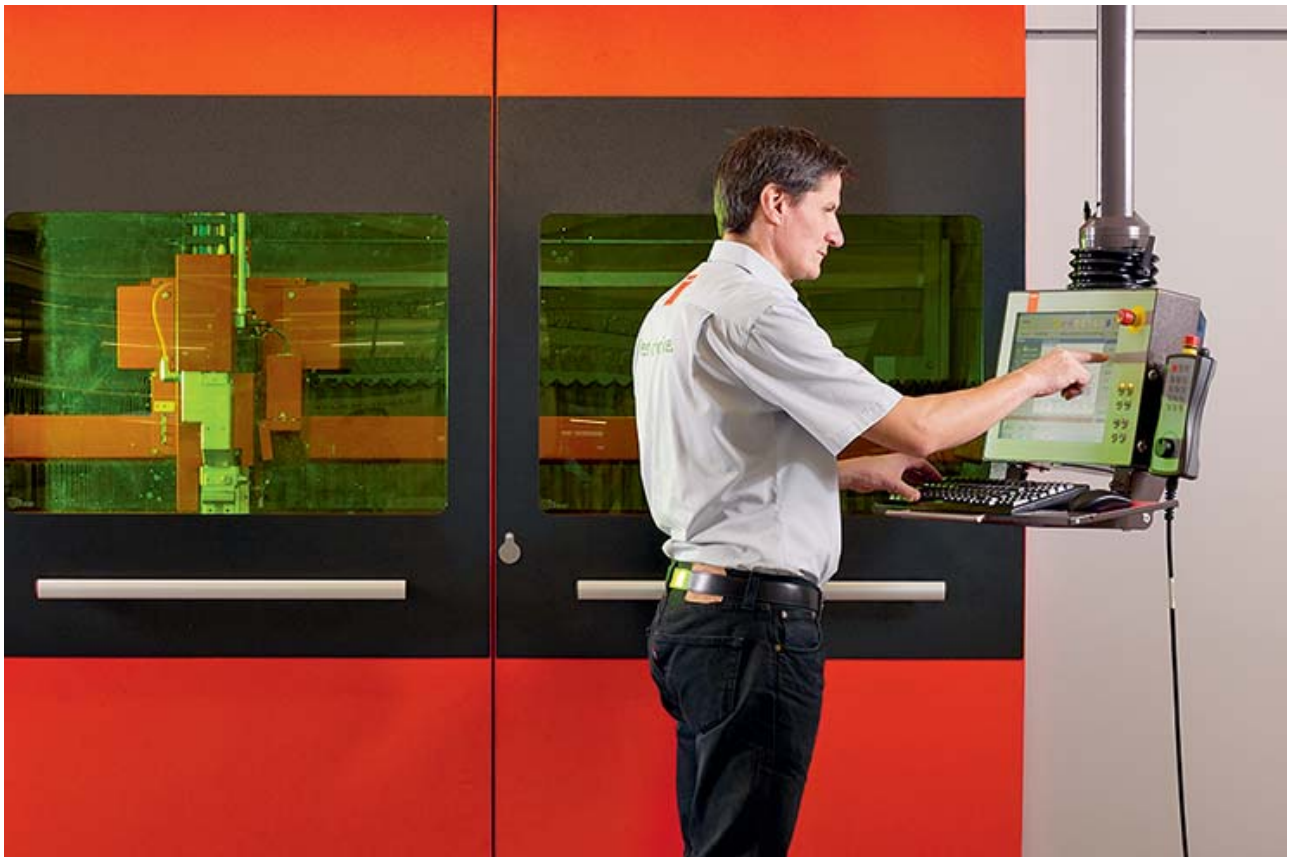


Figure 15: A laser product in a manufacturing area is equipped with a protective housing that provides complete shielding.

6 SN EN 60825-1:2014
7 e.g. SN EN 61508

8 Nominal Ocular Hazard Distance

4.3 Laser controlled area

Laser equipment operators must take suitable measures to ensure that nobody can be unduly irradiated even in areas with openly accessible laser radiation, i.e. that no one is exposed to laser radiation above the maximum permissible level (MPE) in accordance with laser safety standard[9] at all.
This objective can usually only be achieved when these kinds of lasers areas are separated by structural means and are monitored so that they can only be accessed by authorized persons with the necessary protective equipment.

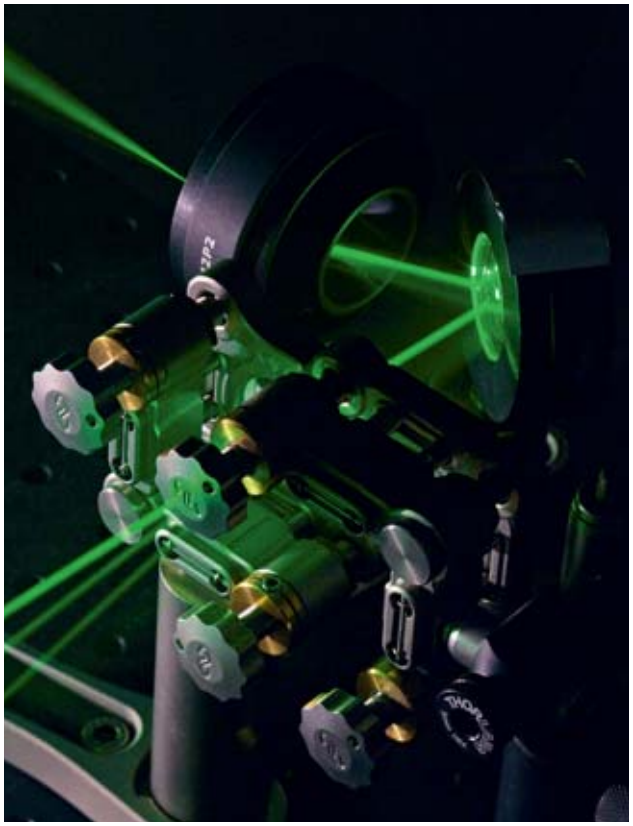


Figure 16: Unshielded lasers may only be operated in a designated area with controlled access.

These are the most important **requirements and protective measures** for operating a laser controlled area:

Laser area boundary
If the structurally segregated area may only be accessible with laser safety eyewear, then the entrance must be configured as an air lock or other means must be taken to prevent radiation from leaving the demarcated area. Transparent or open side walls, doors and windows, must be covered or replaced with suitable material. If this shielding is removable or is comprised of moving parts (e.g. curtain), then the locking mechanism must be coupled to the laser's monitoring system. The wavelength and output of the laser determine which shielding material should be selected. Examples of suitable materials are anodized aluminium (in the visible range) or polycarbonate panels (in the infrared range). The material is considered to be suitable when it is tested according to the standards SN EN 12254 and/or SN EN 60825-4. If there is no certificate, then a self-certification can be performed. It will suffice if the material (such as, e.g. mounting films, blinds or curtains) meets the requirements of your own, individual situation. The certification process must be recorded in writing and the document furnished with the place, date and signature of the person responsible for the test. The certificate is part of the mandatory safety concept and must be presented at the request of the implementing body for occupational safety.

Personal protective equipment
The staff must be equipped with the necessary personal protective equipment, such as e.g. laser safety eyewear. The laser safety eyewear must ideally be made available at the entrance. Additional information on laser safety eyewear is summarized in Appendix A.

Labelling
The entrances to the laser area must be marked in the same way as the corresponding laser products. Appropriate laser warning signs must be attached at the entrances to the areas or to the protective covers used for Class 3B or 4 laser products (see Chapters 3 and 6.2).

Switching device
The laser device must be installed and set up so that it can be operated safely at all times. The switching device must be arranged so that users are not endangered by the radiation.

9 SN EN 60825-1:2014, Appendix A

Operating status display
If the situation requires personal protective equipment to be worn, then notification of the hazardous operating state of a laser device must be clearly visible outside the entrance to the laser controlled area.

Beam delivery
The beam path should be enclosed or shielded whenever possible. The beam must not pass at eye level. The target region must also be encased in such a way that as little scattered light as possible can escape to the outside. To avoid uncontrolled reflections and the associated hazards, only permanently installed superstructures are allowed for Class 4 laser products. The laser and all optical elements are to be secured in such a way that it is impossible for them to be accidentally moved or overturned.

Illumination
Since many safety eyewear also causes a significant attenuation in the visible spectral range, an adequately bright illumination is required. It is expedient to install a dimmer so that the illumination can be sufficiently darkened again when making adjustments.

Escape route
The equipment set-up in the laser controlled area must be designed so that unimpeded escape is possible at all times. It is best to route power, water and measuring lines from above to avoid tripping hazards. Any paraphernalia not belonging to the laser device, particularly flammable paraphernalia, may not be deposited in the laser controlled area.

Incidents
In case an incident should occur, helpers (fire department, ambulance, etc.) should be able to enter at any time without endangering themselves. This can be ensured by a glass compartment installed and plumbed near the entrance, which contains a key and an emergency stop switch.

5 Additional hazards of lasers

Besides the obvious optical hazard, other hazards also arise from the operation and use of laser products. To implement additional measures, it is often necessary to obtain additional information or consult specialists from other areas of occupational safety. The following list of possible hazards is merely an overview and is not intended to be exhaustive.

Fire and explosion

Lasers can cause fires or explosions. All combustible materials such as wood, plastic, paper, etc. or solvents (e.g. for cleaning lenses) must be kept away from the laser beam.

Toxic gases or vapours

Toxic gases or vapours may be produced when materials are processed with lasers. The maximum allowable concentration of toxic gases (MAC value) must be observed[10]. The laser system must be equipped with an appropriate extraction and ventilation[11] system.

Hazards caused by toxic substances

Operation of a laser may require the use of toxic substances (e.g. gases for excimer lasers, zinc selenide lenses for CO_2 lasers or liquids for dye lasers). The safety regulations of the manufacturer or supplier must be observed before such substances are used.

High voltage

High voltage is generally required in order to operate a laser system. Repairs and maintenance work on the system may only be performed by qualified personnel.

Secondary radiation

The processing of materials with lasers can create a plasma. This can result in the emission of secondary radiation (e.g. UV or X-rays). The maximum exposure time must be determined and the source of radiation shielded accordingly.

Thermal hazards

Items that are exposed to laser radiation can become very hot. This may cause burns or fires.

10 see brochure «Grenzwerte am Arbeitsplatz», Suva order no. 1903.d
11 The requirements can be found in the brochure «Schweissen und Schneiden. Schutz vor Rauchen, Stäuben, Gasen und Dämpfen», Suva order no. 44053.d, or from EKAS Directive 6509.

6 Obligations of the distributors

The distributor of a system or a device is required by law[12] to comply with national safety rules and to draw attention to all potential hazards associated with using the device. This chapter provides an overview of what this means specifically. Distributors are considered to be manufacturers, importers, distributors, suppliers, retailers, rental companies or the operator himself if he imports the system directly.

6.1 Classification obligation

The distributor may only hand over the product to the operator when he has assigned a corresponding laser class according to the specifications of the laser safety standard[13]. The classification obligation does not apply if the product is a module that functions only after it is installed in a system. How to classify a laser device is described in a binding manner and in detail in the laser safety standard.

6.2 Labelling

The distributor must label his product in a laser class in accordance with the classification. Refer to the laser safety standard[14] for the exact labelling.

The labelling comprises the following signs:
- Laser warning signs (not for Class 1)
- Class information sign with warning text (all classes)
- Laser data plate with laser emission information (not for Class 1)

Figure 17: Example of a label for a Class 2 laser

The laser warning sign and the class information sign with warning text can also be replaced by the alternative signs (see Chapter 3).

Supplementary signs

The outlet opening of the laser radiation must also be labelled for laser classes 3R, 3B and 4. This can be labelled with the text:
- LASER RADIATION EMISSION
- INVISIBLE LASER RADIATION EMISSION
- or words to that effect.

Alternatively, the following symbol can be used:

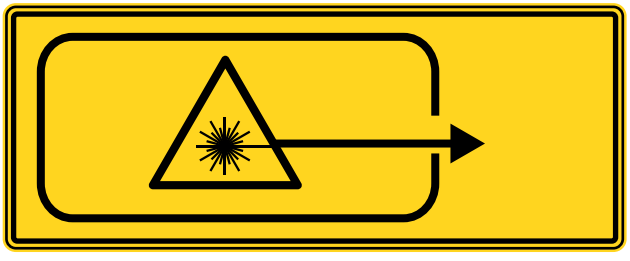


Figure 18: Label for the outlet opening of a laser

12 according to the Federal Law governing Product Safety (PrSG) and the Ordinance on Product Safety (PrSV)
13 SN EN 60825-1:2014
14 SN EN 60825-1:2014

Removable elements
If elements from the protective housing can be removed without tools or their position changed so that stronger laser radiation than Class 1 is accessible as a result, then these elements must be labelled with a laser warning sign and a supplementary sign of the corresponding laser class and the warning text.

Invisible laser radiation
If the laser emits invisible laser radiation, then this must be explicitly pointed out in the warning text. If it emits visible and invisible radiation, then the text must refer to both radiation types.

6.3. Declaration of Conformity and CE marking

In addition to the technical documentation, the manufacturer or distributor must include a Declaration of Conformity in each laser system. With the Declaration of Conformity, the manufacturer certifies that the product complies with the essential health and safety requirements of the relevant European Directives. For laser products, these are in general, the Low Voltage Directive, the Directive on Electromagnetic Compatibility (EMC) and the Machinery Directive. If laser safety standard SN EN 60825-1 is included in the Declaration of Conformity, then it can be assumed that the product was allocated to a corresponding laser class. The CE marking on the product itself attests to the manufacturer's proper implementation of this conformity assessment. In Switzerland the Declaration of Conformity is required, but not the affixing of the CE marking.

CE

Figure 19: CE marking

The Declaration of Conformity is a self-declaration. No type-testing is necessary for laser devices. Obtaining a test report with certificate from a neutral testing and certification body, however, can bring a competitive advantage.

6.4 Operating manual

Figure 20: Each technical product includes an operating manual.

Each technical product includes an operating manual. This must be written in the official Swiss language for the part of the country where the facility or the device is used. The employer or the product owner is responsible for ensuring that people who use the product receive the safety-related information in a form they can understand (if necessary, in their own language).

The operating manual describes how the device is to be used as intended. As regards powerful lasers, it may be useful to draw attention to potential improper or prohibited uses. If particular due diligence must be fulfilled during operation and possibly during installation, then this must be mentioned in the operating manual. The operating manual comprises the safety and operating instructions. Depending on the complexity of the laser equipment, an installation and maintenance manual may still be included.

6.5 Technical safety requirements for laser products

Depending on the laser class, laser products require certain built-in safety devices. A non-exhaustive overview is given below. Refer to the laser safety standard[15] for more detailed information.

Protective enclosure
Class 3B and 4 lasers must have a protective housing if they are not operated in a laser controlled area. All parts of the protective housing that do not have safety interlocks must be secured in such a way that removal is only possible with a tool. Class 4 lasers require that the housing must withstand radiation under reasonably foreseeable single error conditions.

Connection for safety controller
Every Class 3B and Class 4 laser product must have a connector for connecting a safety controller. If the contacts of the connector are open, then the laser must not a pose a danger.

Requirements for electrical safety controllers
Requirements for electrical safety controllers vary depending on the laser class. The exact hazards are to be determined in the context of a risk assessment. The most stringent requirements apply to Class 3B and 4 lasers. In general, the safety lock must function while taking any reasonably foreseeable single error condition into account. This means that, in case of a defect in the electronic safety controller (e.g. a jammed monitored lock or welded switch contacts), the overall safety of the system must be guaranteed. This is assessed, among other things, by the failure probability of safety-relevant components. For this assessment, the SN EN ISO 13849-1 standard is generally invoked (or alternatively the SN EN 62061 standard). Various performance levels are demanded therein for the safety products of a system based on the risk. Class 4 lasers usually require safety products with performance level d or e.

Key switch
Each Class 3B and 4 laser product requires a main switch with key. No laser radiation may be accessible when the key is removed.

Control system
The control system or operating device must be attached so that an operator can adjust all the settings without exposing himself to 3R, 3B or 4 laser class radiation.

Shutter
Class 3B and 4 laser products must have a shutter that can prevent beam emission regardless whether the device is switched on or off.

Warning device
For Class 3R lasers with an invisible beam (wavelength below 400 nm and above 700 nm), and Class 3B and 4 lasers, the warning device must emit an audible or visible signal when the laser system is turned on. The warning device must be fail-safe or redundant. In other words, it must not be possible to operate the laser product with a defective warning device.

15 SN EN 60825-1:2014

7 Additional Information

This list of laws, regulations, standards and other publications is not exhaustive. Any safety regulations not mentioned are also binding. All publications listed here are available on the internet. Standards can be obtained for a charge.

7.1 Laws and regulations

Swiss Federal Accident Insurance Act (UVG) (in particular Art. 82), SR 832.20

Swiss Accident Insurance Regulation (UVV), SR 832.202

Swiss Ordinance on the Prevention of Accidents and Occupational Diseases (VUV) (in particular Art. 3, 6, 43, 50-3, 52a-1), SR 832.30

Swiss Federal Law governing Product Safety (PrSG), SR 930.11

Ordinance on the Protection of Audiences from Exposure to Hazardous Sound Levels and Laser Beams (SLO, Sound Levels and Laser Ordinance), SR 814.49

Medical Devices Ordinance (MedDO), SR 812.213

7.2 Guidelines and additional publications EKAS, Suva, FOPH, ESTI, Swissmedic

- Machinery Directive 2006/42/EC
- Low Voltage Directive 2006/95/EC
- Directive on electromagnetic compatibility of electric and electronic products 2004/108/EC
- EKAS directive: Richtlinie über den Beizug von Arbeitsärzten und anderen Spezialisten der Arbeitssicherheit (ASA-Richtlinie), Appendix 1, Suva order no. 6508.d
- Suva brochure: Grenzwerte am Arbeitsplatz, Suva order no. 1903.d
- Suva leaflet: Schweissen und Schneiden; Schutz vor Rauchen, Stäuben, Gasen und Dämpfen. Suva order no. 44053.d
- EKAS directive: Schweissen, Schneiden und verwandte Verfahren zum Bearbeiten metallischer Werkstoffe. Suva order no. 6509.d
- FOPH leaflet: Lasershows und andere Veranstaltungen mit Laser.
- FOPH leaflet: Vorsicht Laserpointer!
- Allgemeinverfügung des Eidgenössischen Starkstrominspektorates ESTI über das Verbot des Inverkehrbringens von handgeführten, batteriebetriebenen Lasern der Klassen 3B und 4
- Swissmedic leaflet: Anwendung von hochenergetischen Lichtquellen (Laser und Nichtlaser Lichtquellen) in Medizin und Kosmetik

7.3 Standards

SN EN 60825-1:2014 Safety of laser products, Part 1: Equipment classification and requirements

SN EN 60825-2:2004 Safety of laser products, Part 2: Safety of optical fibre communication systems

SN EN 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems

SN EN 60601 Medical electrical equipment

SN EN 60335 Household and similar electrical appliances - Safety

SN EN 12254 Screens for laser working places - Safety requirements and testing

SN EN 60825-4 Safety of laser products. Part 4: Laser guards

SN EN ISO 13849-1 Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design

SN EN 62061 Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic systems

SN EN 208 Personal eye-protection - Eye-protectors for adjustment work on lasers and laser systems (laser adjustment eye-protectors)

SN EN 166 Personal eye protection - Specifications

SN EN 207 Personal eye-protection equipment - Filters and eye-protectors against laser radiation (laser eye-protectors)

EN 11553 Safety of machinery - Laser processing machines

7.4 Helpdesks

FOPH
Federal Office of Public Health
Department of Radiation Protection
3003 Bern

ESTI
Federal Inspectorate for Heavy Current Installations
Luppmenstrasse 1
8320 Fehraltorf Switzerland

METAS
Federal Office of Metrology
Lindenweg 50
3003 Bern-Wabern Switzerland

Electrosuisse
Luppmenstrasse 1
8320 Fehraltorf Switzerland

Skyguide Special Flight Office Switzerland
P.O. Box 23
Flugsicherungsstrasse 1-5
CH-8602 Wangen bei Dübendorf Switzerland

Suva
Physics Sector, Radiation Protection
Rösslimattstrasse 39
6002 Lucerne Switzerland

Swissmedic
Schweizerisches Heilmittelinstitut
Hallerstrasse 7
P.O. Box
3000 Bern 9

Appendix A Laser safety eyewear

Wearing correctly dimensioned laser safety eyewear is mandatory for everyone present when working with or manipulating equipment with Class 3R (invisible only), 3B and 4 lasers.

Laser safety eyewear and filters must always be designed **to protect against the main beam**, even if only scattered radiation occurs.

Laser safety eyewear is **not universal safety eyewear** and may only be used for work with those types of lasers for which it was dimensioned. This means the following parameters must coincide: mode of operation, wavelength range and protection level.

Correctly dimensioned laser safety eyewear attenuates the laser beam at least to the maximum permissible exposure (MPE) and delay it at least 5 s.

Laser full safety eyewear[16] is marked with the critical data on the eyeglass frame: wavelength range, mode of operation (D: Continuous wave, I: Impulse, R: Giant pulse, M: Mode coupled), protection level,[17], manufacturer, certification mark, mechanical strength[18]. Here is an example:

690–1320 D LB6 XYZ DIN S
(Wavelength range: 690-1320 nm, mode of operation: D, protection level: LB6, manufacturer: XYZ, certification mark: DIN, strength: S)

To adjust laser products from classes 3B and 4 with visible radiation, laser adjustment eye-protectors[19] can be worn instead of laser safety eyewear.

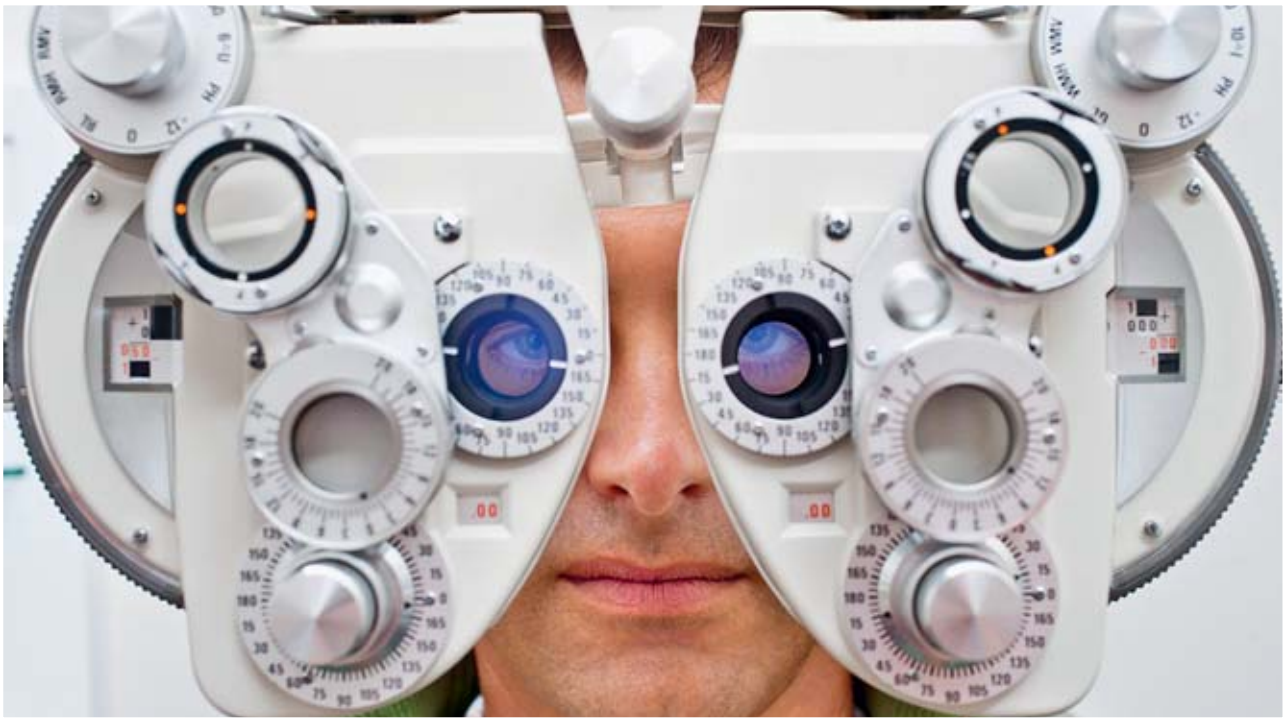
Manufacturers usually provide a dimensioning service to help you select the right laser safety eyewear.

If different lasers with multiple wavelengths are in use, requiring different safety eyewear, the correct choice of safety eyewear must be ensured clearly and by simple means (for example using colour coding).

16 as per SN EN 207

17 see SN EN 207
18 see SN EN 166
19 as per SN EN 208

Appendix B Precautionary eye examinations



Precautionary eye examinations are not recommended for identifying any possible damage caused by lasers. But always seek immediate medical attention after any unintentional, sudden eye exposure!

Damage occurs immediately.
A laser beam is very spatially concentrated and has an extremely high power density. In the event of irradiation by a laser, the harmful effect occurs immediately after the event. Time-delayed effects, for example from an accumulation of several unnoticed hits, are not yet known.

When powerful lasers are handled, i.e. Class 3R, 3B and 4 lasers, vision is particularly vulnerable in the 400 to 1400 nm wavelength range since the focusing effect of the ocular lens concentrates the laser beam onto the area of the retina's sharpest vision (macula). Particularly aggravating is the fact that, once destroyed, sensory cells of the retina cannot regenerate.

The cause is no longer identifiable over time.
Since the retina is subject to the natural ageing process, it is difficult for laser hits to the retina to be differentiated from damage caused by other factors, such as ageing or inflammation, a few weeks after an event. Ophthalmological checkups are therefore problematic. Any identified deterioration in vision is often attributed to unnoticed laser hits, even though this may also be due to the natural ageing process. It therefore makes far more sense to consult a physician immediately after an incident.

Appendix C Checklist for periodic safety audits

This list of questions will help you to create a custom checklist for periodic safety checks. These control questions must be adapted to the local conditions and/or the laser equipment. If you answer one or more questions with no clarifications or measures must be provided.

Checklist

1	Is there a boundary for the laser controlled area?	☐ yes ☐ no
2	Is the access to the laser area controlled?	☐ yes ☐ no
3	Is the enclosure or boundary of the laser beam complete and effective?	☐ yes ☐ no
4	Is laser safety eyewear with the correct protective effect available?	☐ yes ☐ no
5	Is the warning light functional?	☐ yes ☐ no
6	Are the monitoring circuits of the system functional?	☐ yes ☐ no
7	Is the emergency stop switch functional?	☐ yes ☐ no
8	Is the shutter positioned correctly?	☐ yes ☐ no
9	Is an open beam avoided at eye level?	☐ yes ☐ no
10	Is the laser labelled properly?	☐ yes ☐ no
11	Have all reflecting and/or unnecessary objects been removed from the laser controlled area?	☐ yes ☐ no
12	Have all flammable liquids and objects been removed from the laser controlled area?	☐ yes ☐ no
13	Are only project-related workplaces located in the laser controlled area?	☐ yes ☐ no
14	Is a pollutant extraction unit available and functional?	☐ yes ☐ no
15	Have potential tripping hazards been eliminated from the laser conrolled area?	☐ yes ☐ no
16	Are gas cylinder fuses available?	☐ yes ☐ no

Appendix D Laser shows and laser pointers

D.1 Lasers outdoors/Laser shows

Laser events are reportable and must be announced to the relevant cantonal enforcement authority no later than two weeks before they start. The mandatory provisions are specified in the Sound Levels and Laser Ordinance[20]. The organizer is responsible for ensuring that the limit for the maximum permissible exposure (MPE) is observed for all laser radiation that can reach the audience. More information can be found in the publication «Lasershows und andere Veranstaltungen mit Laser» from the Swiss Federal Office of Public Health (FOPH).

If airspace is affected by the use of lasers, then you must seek the prior approval of the relevant air traffic control services. Laser use must be reported with the «Request for coordination of special flights or special aerial activities» application form from Skyguide[21].

D.2 Lasers for private use/Laser pointers

In the public domain, laser pointers repeatedly make the headlines. It therefore happens quite frequently that people are intentionally or unintentionally blinded by lasers. Although the marketing of hand-held pointing devices with Class 3B and 4 lasers is prohibited by the «Allgemeinverfügung über das Verbot des Inverkehrbringens von handgeführten, batteriebetriebenen Lasern der Klassen 3B und 4» by the Federal Inspectorate for Heavy Current Installations (ESTI), after a laser attack it is often difficult to determine what type of laser (or laser class) was actually used. In addition to extreme glare, damage to the eyes or skin caused by exposure from laser pointers is also possible. More information is summarized in the leaflet: «Vorsicht Laserpointer!» from Switzerland's Federal Office of Public Health (FOPH). The information provided by the FOPH and the cantonal authorities must be observed as regards the private use of lasers.

20 SLV, SR 814.49
21 Applications for coordinating specific activities should be sent to the following address: specialflight@skyguide.ch.

Appendix E Maximum permissible exposure (MPE) and accessible emission limits (AEL)

E.1 Maximum permissible exposure

The term maximum permissible exposure (MPE) is used to specify the limits for laser radiation that falls below the known hazard level. For biological reasons, there is no precisely defined differentiation between safe and dangerous exposure. The MPE-values represent the maximum values that the eyes or skin may be exposed to under normal circumstances without becoming directly associated with injuries either immediately or after a long time. The values depend on the irradiated object (eye or skin), wavelength, pulse duration, exposure time and beam geometry.

E.2 Accessible emission limits

The accessible emission limit (AEL) refers to the maximum value of accessible radiation that is permitted within a specific laser class. The accessible emission is the power or energy within certain measuring orifices as defined in the laser safety standard[22]. The accessible emission is compared to the AEL in order to determine the class of the laser product. An estimate is also made from the accessible radiation as to whether, or after which exposure time, the MPE values are exceeded.

Both the AEL and the MPE values can be drawn from the SN EN 60825-1: 2014 standard.

22 SN EN 60825-1:2014

Appendix F Lasers in medicine and cosmetics

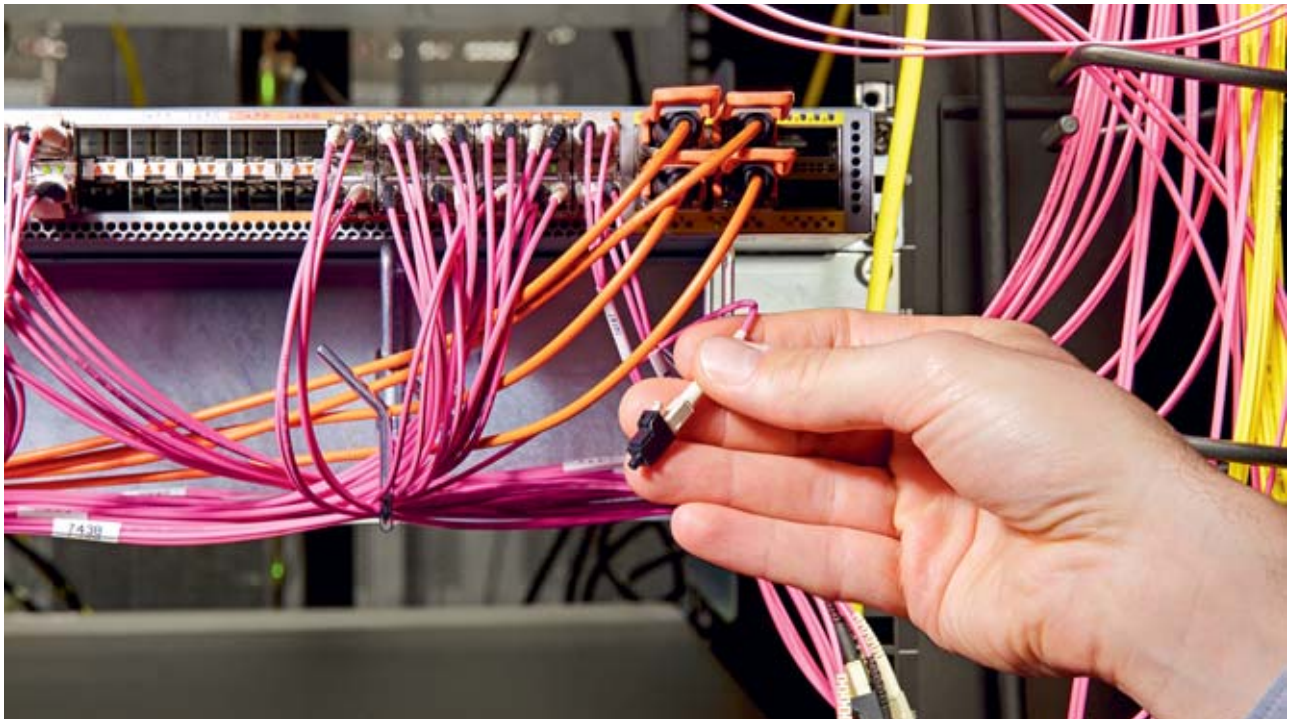
Medical interventions on the human body with lasers may only be performed by a doctor or by a trained person under medical supervision and responsibility.

Laser products with a medical purpose must meet the requirements of the Medical Devices Ordinance[23]. For further information, contact the Swiss Agency for Therapeutic Products, Swissmedic. This organisation is responsible for monitoring the medical product market.[24]

Cosmetic treatments with lasers or high-energy non-coherent light sources (e.g. flash lamps) should ideally be performed under the supervision and responsibility of a physician. Beauticians who perform such treatments should at least have a Swiss Federal Certificate or equivalent education or training and must be adequately trained in operating the device. You can find more information on this subject from the Swiss Federal Office of Public Health (FOPH).

23 MedDO, SR 812.213
24 see leaflet Swissmedic: «Anwendung von hochenergetischen Lichtquellen (Laser und Nichtlaser Lichtquellen) in Medizin und Kosmetik»

Appendix G Safety requirements for fibre-optic communication systems



Here you will find an overview of the applicable Swiss legislation in the area of occupational health and safety as regards optical fibre communication systems (OFCS). This overview lists the most important requirements and measures for businesses and organizations that manufacture, install, repair or operate optical fibre communication systems or modules.

The «Grenzwerte am Arbeitsplatz»[25] brochure declares Part 2 of the laser safety standard on the safety of optical fibre communication systems[26] in Switzerland as binding. In general, the following information is based on this standard.

G.1 Safety concept

G.1.1 Classification of locations and degrees of exposure

In contrast to open lasers, emissions from OFCS are accessible only under certain conditions (open fibre or break). That is why these are classified into different exposure degrees based on wavelength and output. Each accessible point of a system must be assigned an exposure degree to indicate the potential hazard from accessible exposure at this location. The degree of exposure must be determined by a calculation or measurement of the optical emission (which is accessible under reasonably foreseeable conditions). The classification of the hazard level is analogous to the system of laser classes as per Part 1 of the laser safety standard[27] (see Chapter 3).

25 Suva order no. 1903.d
26 SN EN-60825-2:2004

27 SN EN 60825-1:2014

Based on these hazard degrees, each workplace must be subsequently assigned one of three possible location types:

- **Unrestricted location:** no measures required to restrict public access. At unrestricted locations, the maximum permissible hazard levels are 1M and 2M; on plug connections, hazard levels 1 and 2 only.
- **Restricted location:** not accessible to the public. Access possible without instruction in laser safety, but only for authorized persons. At restricted locations, the maximum permissible hazard level is 3R; on plug connections, exposure degrees 1M and 2M only.
- **Controlled location:** access only for authorized persons with instruction in laser safety. At monitored locations, the maximum permissible hazard level is 3B; on plug connections, exposure degrees 1M and 2M only.

Locations with hazard level 4 are not permitted.
The transmission of Class 4 laser outputs is only permitted when this output cannot be accessed.

A location's degree of exposure can be reduced using technical means, for example,:
- by using cable connectors, which can only be opened with a tool
- by using systems for automatic output reduction. These must decrease the output within 1 second (in unrestricted locations) or 3 seconds (in restricted and monitored locations) to the acceptable limits and may not have any automatic restart function.

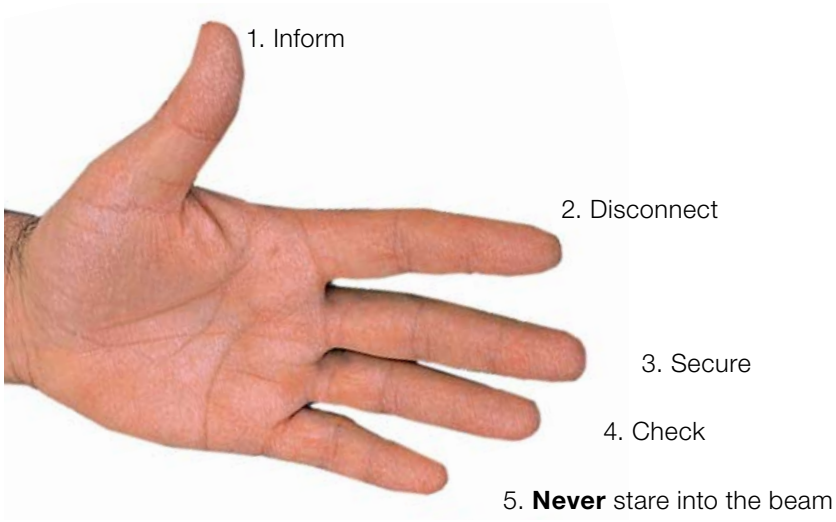
G.1.2 Labelling
It is always necessary to label the particular location type, except at locations that do not have an hazard level higher than 1. Fibre-optic cables must also be clearly differentiated from other cables (e. g. power cables). Where hazard level 1 is exceeded, then each connection that can emit radiation when opened must be labelled according to the information from Part 2 of the laser safety standard[28]. The standard also defines the requirements for the content, form and durability of the labels.

G.1.3 Personnel training
Employees who erect or maintain fibre-optic communication systems must receive appropriate training on exposure degrees from an expert on laser safety. Persons who enter locations with a hazard level 3B and persons who are responsible for the installation or repair of an OFCS system must receive training at least once per year. This training must be documented.

G.1.4 Other protective measures
The following protective measures must generally be observed:
- Any work in special operation and during maintenance requires that the system be brought into a non-hazardous state before work is started.
- The highest hazard level must be assumed in unlabelled locations.
- Any missing location identification labelling must be supplied immediately or reported to the responsible operator.
- Fibre fractions must be collected in a suitable container since they may cause skin and eye injuries. In addition, eating and drinking at the workplace is prohibited.

28 SN EN-60825-2:2004

G.1.5 The 5-point rule



1. All participating firms and individuals must be sufficiently informed when working on OFCS.
2. The light signal must be disconnected beforehand wherever possible in order to effectively avoid a hazard.
3. There are several ways to secure the system, for example: Lock the room, attach a padlock to the safety switch, use a dummy plug with a warning, etc.
4. Use a measuring device to check if a light signal is still present.
5. There is never a reason to stare into a fibre-optic cable, irrespective of distance!

G.2 Obligations for all participating companies

The most important tasks and obligations for manufacturers, owners, operators, maintenance staff and repairers of fibre-optic communication systems are listed here. If in doubt, the laser standard[29] shall apply.

Businesses in general
- instruct their own staff
- make agreements and inform their partners as regards cooperation

The manufacturer
- shall ensure that the system meets the requirements of the standard
- must issue a Declaration of Conformity for its products
- shall provide all the necessary information in order to operate the device safely

Contracting businesses
- shall inform the personnel they appoint from other businesses
- shall demand compliance with the safety regulations from the businesses appointed by them
- shall record this requirement in the contract
- shall monitor compliance with the provisions and intervene when necessary

The owner
- shall inform the tenant about the hazard posed by his system (e.g. the maximum permissible hazard level)
- shall provide the means for access control (e.g. lockable locations)
- shall demand compliance with the safety regulations in the contract
- shall monitor compliance with the provisions
- shall be liable for any damages resulting from a faulty system or improper maintenance

The operator
- shall classify and evaluate the locations used by him and label them
- shall control any access to the locations
- shall ensure that when adjustments to the systems are made, the hazard level of all locations will remain unchanged or that any access authorization and labelling are adapted
- shall draw up safety instructions and monitor their application
- shall demand compliance with the safety regulations from the businesses appointed by him

Maintenance technician and repairer
- shall ensure that the equipment is brought into a non-hazardous state before starting work prior to maintenance and for special operation
- shall ensure that their personnel work according to the operational safety regulations
- shall provide their own personnel with the necessary protective equipment
- shall ensure that the location descriptions are correct during the work assignment and after leaving the location
- shall ensure that the access regulations are adhered to during the work assignment and that the access restrictions for normal operation function properly after leaving the location

29 SN EN 60825-2:2004

Suva
Health protection
P. O. Box, 6002 Lucerne

Information
Tel. 041 419 61 33

Download
www.suva.ch/waswo/66049

Title
Caution: laser beam!

Author
Roland Krischek, Physics Sector

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