The document describes the process and the governing rules for planning and setting up laser laboratories at PSI in order to allow safe operation of such infrastructure. The rules apply to all PSI laser laboratories with class 3b and class 4 lasers in use.

In the event of discrepancies between the German and English versions of this document, only the German version is binding.

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1 Applicable documents

The most important documents applicable for the present document are named below.

1.1 Internal documents

- FMEA zum jeweiligen Lasersystem
- AW-01-07-02 Sicherheit Gesundheitsschutz und Umweltschutz
- AW-96-19-176 Arbeitssicherheit und Gesundheitsschutz am PSI
- AW-93-05-02 Sicherheit beim Umgang mit elektrischen Anlagen und Geräten am PSI (D)
- AW-93-05-03.3 Sicherheitskonzept zu den Versuchsaufbauten am PSI
- PB-9670-36 Umgang mit Laser
- PB-9670-217 Planung und Einrichtung von Laserlaboren am PSI
- PB-9670-214 Einsatz und Betrieb von am PSI hergestellten und eingesetzten Geräten und Anlagen zu Forschungszwecken

1.2 External documents

- Suva Broschüre Nr. 66049 «Achtung Laserstrahl»
- VDE-Bestimmung (DIN EN 60825 und VDE 0837) «Sicherheit von Laser-Einrichtungen»

2 Scope of the document

The process description regulates planning and setting up of laser laboratories at PSI in order to enable a safe operation. It applies to all laser laboratories at PSI with lasers of class 3B or higher in operation. The process description applies to all operators and laboratory managers who operate lasers and such systems at PSI. The document is subject to a 3-years validity check.

3 Objective

Protection of people against possible laser radiation exposure. It includes the protection of the instructed laser experts as well.

4 Technical terms

Class 3B laser:
Laser with a continuous wave power of 0.5 W max. Looking directly into the beam or into a reflection caused by a specular surface can lead to eye damage even at short exposure times. Scattered radiation from a non-reflecting surface usually does not damage the eyes (minimum distance of 130 mm for 10 s max.).

Class 4 laser:
Laser with a continuous wave power > 0.5 W for the invisible and visible spectrum, as well. The laser power is unlimited. The primary beam, as well as the reflected or scattered radiation, cause seriously damage to eyes and skin. Exposure to certain materials may release harmful substances, cause explosions or fire.

**Performance Level (PL)**
Discrete level, which specifies the ability of safety-related parts of a controlling unit in order to perform a safety measure under predictable conditions.

**Entrance /Labyrinth:**
A labyrinth can either be a permanently installed curtain (certified for lasers), or a wall behind the access door that prevents the laser beam from escaping the hazardous area. If the entrance/labyrinth is accessible because the curtain cannot be firmly closed, it is mandatory that an implemented control system is checking whether the curtain is closed or not before the laser switches on (interlock). Additionally, the laser must switch off automatically or the shutter put in the closed position automatically when the entrance door opens during laser operation and the curtain is not fully closed.

## 5 Laser safety at PSI

A detailed risk analysis is mandatory for a newly established laser laboratory or new laser installations at PSI. This way, the operator assesses the risks associated with laser operation and defines the measures to minimize them. Possible discrepancies from the below mentioned guidelines can be detected and assessed. For lasers of class 3B and 4, SUVA makes increased demands on the electrical safety control. If not otherwise defined in the risk analysis, class 4 lasers generally require safety devices with a PL d.

Laser safety in PSI laser laboratories is ensured by technical and organizational measures. In particular, these are:

- All employees working in laboratories with lasers in operation are instructed. The instruction must be documented by the laboratory responsible;
- Wearing personal protective equipment (laser safety glasses) during laser operation;
- Access to the laboratory is restricted by means of Interflex and personal badge;
- A laser warning lamp indicates laser operation;
- A green lamp indicates the area is accessible;
- The functionality of the safety control system must be checked and track-recorded annually and after new laser installations by the laboratory responsible;
- A labyrinth (closed laser curtain or a wall) is installed behind the entrance door. A labyrinth prevents people in front of the laser laboratory from being exposed to radiation;
- An audible signal is triggered after 30 seconds if the entrance door remained accidentally open;
- A key switch is installed to the laser or its control unit. It is impossible to switch on the laser with removed key;
- An emergency stop button must be installed in front of the respective room. The button is pushed by the fire brigade and/or by medical personnel in the case of emergency before entering the room. The emergency stop sets the laser into a safe state. The room is safely accessible if the green lamp is on (if present, see 5.1).

Additionally, the control measures defined in Chapter 5.1 and 5.2 must be implemented for the following situations.

1. Laboratories with a laser installed outside the room. The laser is not visible by the operator. The operating mode “laser” to “free” changes frequently.
2. Laboratories with a laser installed in the room. The laser is visible by the operator. The laser laboratory is a permanent facility. Non-specialists enter the laboratory only rarely for installation and service work.

5.1 Laser outside the laser laboratory

Three laser operating modes are available:

1. Laser mode: The laser beam can be propagated in the room, necessary for laser alignment and experiments. Such tasks involve working with class 3B or higher class lasers with direct access to the beam.

2. Free mode: The operation of class 3B or higher class lasers is forbidden. The emission of laser light is impossible. The following measures apply: the laser source is off, the safety shutter between laser aperture and the room is in closed position or the laser is encapsulated by a lightproof housing. The laser warning lamp is off. If it is impossible to switch off the laser power supply in the event of a fault, the proper operation of the laser control unit (safe access) must be indicated by a green light. Access restrictions for the entrance door do not apply. All other personnel has access to the laboratory.

3. Locked mode: The access door is locked. Entrance is impossible. Laser operation is possible.

A critical point is switching from laser mode to free mode. Laser emission has to be prohibited e.g. by closing the shutter or switching off the laser (unpowered state). A controller for such a functionality has to be implemented. The controller must be designed with a two channels architecture for redundancy reasons. Component failure must be avoided in any case.

The component that prevents laser emission must be designed with a two-channel feedback. A combination of individual safety elements (e.g. shutter) is also permitted.

If the laser has an interlock signal with PL certification of class D (PL d), this signal can be used for safe shutdown. If this is not the case, PSI uses either self-made or commercial shutters with position switches without PL certification. To guarantee redundancy in this case, two shutters are installed one behind the other and evaluated independently of each other. If the feedback of one or both shutters is incorrect, the laser warning lamp must remain on and the green light off (if a light is present). The laser mode is retained and an acoustic alarm triggered.

The laser warning lamp is off, the green light is on (if a light is present), and the access restriction is invalid when both shutters are in the position “closed”.

5.2 Laser installed in the laser laboratory

In normal operation, only trained personnel has access to the laser laboratory.

Two operating modes are available:

1. Laser mode: for laser alignment and experiments. Such tasks involve working with a class 3B or higher class laser with direct access to the laser beam.

2. Free mode: Laser is off.

In order to switch safely from laser mode to free mode, it must be ensured that the laser is unpowered (off). The laser main power supply is switched off by turning the key switch. The laser warning lamp is off and the
green light (if a light is present) is on. The control unit must be designed with a two channels architecture for
redundancy reasons. Endangering people by a component failure must be avoided.

As described in 5.1, the interlock signal can also be used to switch off, if the interlock signal has a PL d certi-
fication.

Shutters as described in 5.1 are allowed for use. However, it must be ensured by the laboratory responsible
that those shutters cannot get removed and no laser light is escaping from the aperture (not even through
reflections).

6 Responsibilities

The laboratory responsible is responsible for the design, the set-up, the maintenance and the inspection of
the system on a regular basis.

7 Who is in charge

Tasks of the laboratory responsible:

• Creates the risk assessment, system description and operating instructions in cooperation with the «Pro-
cess attendant machine safety» from the respective PSI division;

• Ensures that all employees, who work in the laser laboratory, are instructed and that the instruction is
documented;

• Monitors the wearing of laser safety glasses;

• Checks access authorizations on a regular basis;

• Checks the control system functionality on a regular basis (annually or when connecting a new laser);

• Establishs the labyrinth.

Tasks of the control systems section:

• Development of the implementation concept;

• Checking the implementation according to the implementation concept.

Tasks of the section electrical systems, electrical supply:

• Realization and wiring.

Tasks of the safety section and the laser safety specialist PSI

• Controlling whether all protective measures defined in the risk assessment and in this document are con-
sidered properly before commissioning.