Universiteit Leiden

Laser Safety Handbook

Version 1.0

Prepared by the Leiden University Steering Committee on Laser Safety

Approved by the Executive Board of Leiden University, September 2016

Preface

The ‘Laser Safety Handbook’ was prepared by the steering committee for laser safety of Leiden University (LU). This document describes the management of laser safety for all departments within LU wherein lasers are in use. The document is intended only as a local interpretation of Dutch law and regulations and international best practice in the area of laser safety. The document augments the general Safety and the Environment policy of the faculties, which covers occupational hygiene and environmental aspects related to the workplace. This handbook covers all laser facilities and installations, regardless of the class in which the laser falls.

The ‘Laser Safety Handbook’ is intended to facilitate the implementation of a uniform laser safety policy within LU and is intended for distribution to all personnel that hold responsibility for laser safety (laser safety manager (VGM), laser safety officers (on faculty level) and local supervisors). It is also a handbook for general distribution, made available in digital form via the LU website.

July, 2016

Table of contents

1. Organisation

The Higher education and scientific research act (WHW) stipulates the management structure of universities and their actual tasks: education and research.
The management structures with direct responsibility for laser safety are described in this section.

Executive Board of the University
The Executive Board of the university (CvB) carries the accountabillity for strategic management and the day to day operation of the university as a whole. Responsibility for laser safety is within its remit.
The Executive Board of the University is the legal entity responsible for this task.

Faculty Board
The Faculty Board, by mandate, is accountable for the general management of the faculty and is directly responsible for the implementation of management tasks, including laser safety as directed by the CvB and the tasks delegated to it.

Scientific Directors
The Faculty of Science is subdivided into several Research Institutes. The Scientific Directors of the research institutes have been given, by mandate, complete responsibility for the working conditions, including laser safety, and environmental protection within their institute.

Laser Safety Organisation
The laser safety organisation was established by LU with the goal of realising its laser safety objectives. The organisation is comprised of the faculty of Science and the faculty of Archaeology wherein class 3R, 3B and 4 laser systems are in operation. At a central level, the HSE department (VGM) administrate the supervisory functions of the Executive Board of the University with regard to working with lasers, fulfilling the statuary obligations that are relevant to these activities. At faculty level, the supervisory functions reside with the laser safety officers (LSO's). A steering committee exists for laser safety. The steering committee is comprised of the laser safety officer(s) of the faculties and the laser safety manager (VGM).

The laser safety officer is responsible for (the organisation of) the supervision of facilities within their faculty. A local laser safety supervisor is assigned responsibility for each laser lab or laser facility and has direct responsibility for operations and applications. Organisationally, those responsible are referred to as local supervisors. At every level of the organisation, central, and local at each laser lab or laser facility a laser safety dossier is maintained. The management structure is described in the organogram below (figure 1.)

Operationally and hierarchically the laser safety officer and laser safety manager are answerable to the Executive Board of the University and the laser safety officer to the Faculty Board. The laser safety manager is appointed by the Executive Board of the University, the laser safety officer is appointed by the Faculty Board and the local supervisors are appointed by the Scientific Director of the research institute.

Consultation structure
The roles of the steering committee for laser safety are to function as consultants on laser safety, the preparation of Leiden University's laser safety statement and the preparation of recommendations to the faculty board, research institutes and where appropriate the Executive Board of the University. In addition, the committee serves to ensure consistency in safety requirements and the dissemination of best practice in the area and is the contact point between the local supervisor and

the laser safety manager. The steering committee for laser safety meets on a regular basis. Minutes of the meeting are reported and are available on request.

The laser safety officer maintains a central registry of all high power lasers (class 3R, 3B and 4). The registry is updated by the local supervisors when new lasers are purchased, when the location of existing lasers is changed and when changes to the laser's use or arrangement affect the risks involved in using the laser system. Actuality of the status updates and the progress in execution of the risk evaluations are monitored by the laser safety manager.

Local consultation
For each location the laser safety officers, where required, engage in structured consultation with local supervisors, including providing expert advice and ensure implementation of laser safety policy within their location(s) and verification of implementation.

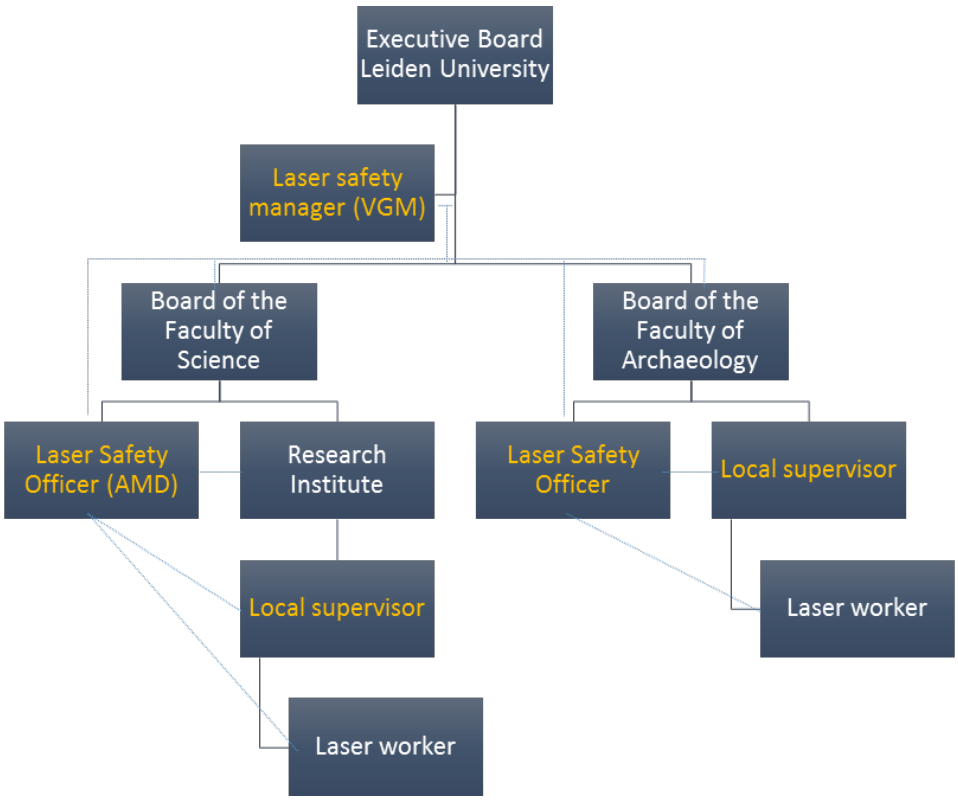

figure 1. Organisation of laser safety. The laser safety steering commitee is comprised of the laser safety manager and the laser safety officer(s).

2. Definition, appointment and task assignment for staff regarding laser safety

Scientific Director of the research institute
The scientific director of the research institute is accountable for ensuring the implementation of safety regulations as defined by the Faculty Board. The director delegates the responsibility for the implementation of safety regulations, in accordance with the guidelines and instructions of the designated laser safety officer, to scientific and technical staff responsible for supervision, operation and maintenance of facilities wherein lasers are used (via local supervisors towards the laser workers). Tasks can be delegated only to permanent employees and employees with a tenure track appointment.

Laser Safety Manager (VGM)
It is the duty of the Executive Board of the University to appoint a suitable person to this position. The laser safety manager must hold a diploma or *curriculum vitae*, in which the necessary competencies are apparent with regard to laser safety management, as described in NPR-CLC/TR 50448:2005.

The role of the laser safety manager is primarily to act as a source of professional and independent advice in the area of laser safety. The laser safety manager shall provide, solicited and unsolicited, advice to the Executive Board of the University and the personnel that form the laser safety organisation. The laser safety manager monitores the laser safety organisation from a strategic perspective in terms of evaluation and auditing, to secure the continuity of the laser safety organisation. In the case of situations of acute laser related risks, the laser safety manager is empowered to order that the laser facility ceases operations until the risks involved have been removed.

The actual tasks of the laser safety manager are:
- Management of the laser safety organization,
- Coordination and assessment for general laser safety management for LU,
- Chairing, planning and reporting of meetings of the steering committee for laser safety,
- Formal handling of nominations for appointments of laser safety officers,
- Solicited and unsolicited advice at a central and decentralised level with respect to all aspects of laser safety,
- Handling of incidents and contact point for the SZW Inspectorate,
- Annual reporting to the CvB via a laser safety chapter in the annual report on radiation safety,
- Holds the authority to implement limitations to discontinuation of the use of a laser or a laser system when he/she considers it unsafe.

Laser Safety Officer
It is the responsibility of the Faculty Board, on the basis of a recommendation of the steering committee on laser safety, to appoint a suitable person to the position of laser safety officer. The laser safety officer holds a formal diploma or *curriculum vitae* wherein the competencies with regard to laser safety are present (in accordance with the 'guide to levels of suitability with respect to laser safety', NPR-CLC/TR 50448:2005), as adjudged by the steering committee for laser safety.

The laser safety officer has advisory, verification and enforcing roles. The laser safety officer carries out inspections of laser facilities and advises in matters of laser use, practical laser safety aspects, procedures etc. The primary task of the laser safety officer is to ensure the safe use of lasers within

their location, on behalf of the faculty board. The laser safety officer shall ensure that lasers are used within the guidelines set out by the management of the university and the relevant laws and regulations in the area of laser safety. The laser safety officer shall function as a source for advice in the area of laser safety for staff and students whose tasks involve the use of laser equipment. The laser safety officer must ensure that all written safety instructions are followed up on and that her or his name is stated clearly on the instructions. The laser safety officer must have knowledge of the relevant standards and all relevant laws and the manner in which these affect working with laser radiation and must also be fully satisfied with the organisations own regulations and safety instructions. The de facto tasks of a laser safety officer are dependent on the laser application(s):

- Maintaining the central registry of class 3R, 3B and 4 lasers and laser facilities,
- Ensuring that risk inventory and evaluations (RI&E) are carried out and/or updated when newly registered laser systems and laser systems that have been taken out of stock are going to be used,
- Coordination of and carrying out safety audits,
- Ensure that sufficient education and training is provided to the personnel that work with or have access to the lasers,
- Ensure the fulfilment of laser safety administration, with regard to education and audits,
- Classification or verification of the classification of lasers and laser products,
- Holds responsibility for the identification and assessment of hazards and risks presented by laser rooms,
- Ensuring that the prescribed regulations are observed and recommend or approve alternative regulations when the primary regulations are not implementable or are impractical,
- Approval of instructions, protocols or other procedures that are necessary for the safe use of lasers and laser applications,
- Implementation or approval of protective measures, such as glasses, clothes and screens, etc. as necessary for the safety of personnel,
- Approval of the text and lay-out of room signs and equipment labels,
- Approval of all new or modified laser facilities / laboratories and laser equipment before installation,
- Provide support to users and management with regard to matters related to laser safety,
- Holds the authority to implement limitations to or discontinuation of the use of a laser or a laser system when he/she considers it unsafe,
- Informing the Scientific Directors of the research institute and research groups with regard to developments in the area of laser safety, in so far as continuity within the research institute or research group(s) is affected,
- Alerting the laser safety manager and the Scientific Director of the research institute and research group(s) of situations in which the use of laser facilities or a laser system has been stopped, where it has been found to be unsafe,
- Investigation of incidents and accidents including near-accidents (accidents that could have led to injury, including un-authorised access),
- Maintenance of the laser safety system within the faculty.

Substitution
In order to maintain continuity within the laser safety organisation every laser safety officer must have a replacement available, whom in case of absence, can take over tasks.

Local supervisor
At the Faculty of Science, it is the responsibility of the Scientific Director of the research institute to appoint a local supervisor, where class 3R, 3B and/or 4 lasers are in use as part of research or teaching assignments. At the Faculty of Archeology this is the responsibility of the Faculty Board.

Local supervisors are permanent employees or tenure tracked staff members and, are appointed on the approval of the steering committee for laser safety. The local supervisor should, as a minimum criterium, hold a formal diploma in which the necessary competencies are demonstrated with regard to laser safety or on the basis of sufficient demonstrable competencies (as described in the 'guide to levels of suitability in laser safety', NPR-CLC/TR 50448:2005) in the opinion of the laser safety steering committee.

The local supervisor is responsible for the implementation of regulations and procedures that are laid out in the risk inventory(ies) and this handbook. The local supervisor should provide sufficient guidance to staff and students (both bachelor and master) and ensure that they work in a manner in accordance with the risk inventory and the university's safety policy. Laser workers who do not work in accordance with the relevant regulations are to be denied access. Local instruction is to be given by the local supervisor except in exceptional cases where it is given by the laser safety officer or a deputy. This task cannot be delegated. Persons with eye defects (other than the wearing of glasses) must first consult the company doctor before being appointed as laser worker.

The tasks of the local supervisor are to:

- Ensure that access to laser facilities is limited to authorized personnel and maintain the list of trained laser workers,
- Ensure that the possibility of operation of lasers within the laser facilities is controlled (e.g., through the secure storage of keys),
- Provide safety instructions required for personnel entering the laser facility,
- Provide work instructions for the safe operation of the laser to personnel working in the laser facility under all forseeable conditions, e.g normal use, maintenance, alignment conditions, etc.
- Identify activities or mistakes with regard to procedures that are contrary to the regulations within the laser facility and report them to the laser safety officer,
- Take immediate and appropriate action in cases of such violations or mistakes,
- Report to the designated laser safety officer activities or errors in procedures that are not in accordance with applicable regulations,
- Make recommendations on changes to procedures and protocols to the laser safety officers and, where relevant, the Scientific Director of the basic research unit,
- Take responsibility for the safe day to day operation and arrangement of laser laboratories,
- Assist the laser safety officer during audits.

Laser worker
Appointment of laser workers is documented locally. Every staff member, student or guest researcher must complete the registration form for laser workers that is available on the Leiden University website. The form is to be stored by the local supervisor in a dedicated dossier. Safety training and instructions with regard to specific features of the laser laboratory involved are to be provided. After training has been completed, the local supervisor signs the application for access as a laser worker, in which the applicant confirms that he/she has read and understood the laser safety instructions and declares that he/she will work in accordance with current regulations relating to the laser facility. Assessment of the physiological state of the applicant is a component of the induction.

A staff member or student must be accompanied by a local supervisor or experienced laser worker, until this person deems that sufficient experience has been gained to carry out tasks safely. Persons that work for more than three months with a laser system must follow a formal course ‘laser safety for the laser worker’, hold a formal qualification in which necessary competencies with respect to laser safety are apparent, or on the basis of acquired skills can demonstrate sufficient expertise (as described in the 'guide to levels of suitability in laser safety', NPR-CLC/TR 50448:2005), at the discretion of the local supervisor.

Guests

Guests can only be admitted to the laser facility under the supervision of the local laser supervisor. In the case of temporary researchers full laser safety instructions must be provided before they are provided access to work in the laser facility.

3. Administrative requirements

The management of a laser application can be, depending on the laser class involved, subject to administrative requirements. In this regard the classification of the laser system is normative. Mediaplayers, media recording and traditional laser printing devices (not 3D printers) are exempt. **Prior to the purchase of a laser application, the laser safety officer must be contacted.**

Registration of laser equipment
All class 3R, 3B and 4 laser equipment must be registered. *Example: A laser confocal microscope is a class 1 laser product, but within the system there is a class 3B laser system. Therefore this system must be registered.* The registration is handled centrally by the AMD. An online registration form can be found at the Leiden University website or obtained from the LSO via lasers@science.leidenuniv.nl.

Risk-inventory
In addition to the registration of each class 3R, 3B or 4 laser a documented risk assessment (RI&E) for the registered lasers in use must be carried out. **The appropriate laser safety officer must be consulted in the preparation of a RI&E.**

The report contains an inventory of (potential) risks associated with the operation of every laser or laser system within the faculty. The report must be prepared in accordance with the provisions in chapter 6, section 4 'Kunstmatige Optische straling' (Artificial optical radiation) in the 'Arbeidsomstandighedenbesluit' (working conditions decree)'. All required measures should be described within the report. The risk of damage to the eye or skin should be detailed. The central point is to prevent exposure to a laser beam with an intensity above the maximum permitted exposure threshold (MPE-value). Furthermore, it must be impossible for non-laser workers to be exposed to laser radiation that exceeds the MPE value, even though improper use of equipment. Through the implementation of regulations and procedures, wherein the use of appropriate laser safety glasses are included, laser workers can avoid exposure to laser radiation that exceeds the MPE-value. The report describes how access to service staff and emergency services is arranged in the event of a calamity. In addition to the risk of eye injury, risks unrelated to the laser beam itself should be described, such as the use of laser dyes (possible carcinogens/toxins).

Laser facilities
The correct room classification signs must be displayed on the exterior of the entrance door, given by the "Regeling ruimtesignalering Universiteit Leiden". Risk assessments should be available for all activities that are to be carried out within the facility, specifying the room requirements (see chapter 5). Warning signs to indicate the state of laser use should be present (depending on the outcome of the laser RI&E for class 3R and 3B). Maximum safety in working conditions should be pursued, both in terms of cleanliness, laboratory layout, facilities support and infrastructure. Laser activities should not be combined with other non-laser related research in the same room.

4. Training / Education

Requirements for the training of the various laser safety personnel are set out in this manual. Regular laser safety training is provided within the University, under the organisation of the LSO. This is implemented on two levels: the level of the laser worker and the level of supervisory professional (laser safety officer and local supervisor). The programs meet the requirements of the 'guidance for levels of suitability required in laser safety' NPR-CLC/TR 50448:2005. More information on these courses, course fees or course schedules is available from the LSO.

Elements treated in the course include:

- Risk awareness in the area of laser safety
- Knowledge of the principle of operation of lasers and the application of lasers on a day to day basis
- Knowledge of specific risks in the field of laser safety. Both with regard to laser beams and other risks
- Knowledge of the classification of lasers
- Introduction to the law and standards in the area of laser safety
- Knowledge of required warning signs
- Knowledge of the meaning of the exposure parameters MPE, NOHD and (NS)HD
- Knowledge of need for technical and organisational regulations in the area of laser safety
- Knowledge of the application of personal protective equipment to protect against laser beams and associated risks (including the verification of the suitability of laser safety glasses)
- How to read a laser safety RI&E, including understanding the parameters and terminology used therein.

5. Working with lasers

Working with class 3R, 3B and 4 lasers
Operation of class 3R, 3B and class 4 lasers within a laser facility requires that the laboratory is properly equipped and maintained to minimize the risk of accidental exposure. Access to the laser facility is restricted to authorised personnel only.

In order to maintain uniformity, changing a laboratory into a laser room or discontinuation of a laser facility within the Faculty of Science is subject to the faculty's Management-of-Change procedure.

Refer to appendix 2 for the standard design requirements for a laser laboratory. In the case of transitional arrangements being applicable, the result of the RI&E is the basis for the assessment. A number of standard requirements are described below:

In the case of rooms where class 3B or 4 lasers are in operation, an illuminated warning sign must be placed on the exterior side(s) of the access door(s). The text 'laser on' should be illuminated (yellow on black) when power is delivered to the laser. In addition to the illuminated warning sign on the door(s) the appropriate room classification sign should be present in accordance with the "Regeling ruimtesignalering Universiteit Leiden".

The RI&E will provide measures for access control to prevent exposure to laser radiation above MPE-levels.

In the event of a (potential) emergency, an emergency power cutting switch/knob must be available to disconnect the laser systems from the power supply in case of class 4 lasers. To this end an interlock break-out-box must be placed at the point of operation of the laser.

Additional emergency control systems can be present as a stated measure in the general safety chain (e.g. to power off a room in case of emergency intervention).

Whenever the laser is in use ('laser on' should be illuminated), it is not permitted for unauthorized personnel (including building managers, cleaners and maintenance workers) to enter the room without first contacting the local supervisor of the room. Contact information should be present on the door. In the case of an emergency where immediate entry is necessary, the RI&E will state appropriate measures for safe entrance control.

When operating a class 4 laser, special attention must be paid to fire safety when the laser is in use and the arrangement of the laser, to ensure that ignition of materials by the laser is precluded. In this case, the laser room must be provided with a CO_2-extinguisher.

Operational Instructions
Operational instructions should be prepared for normal operation and, if applicable, for maintenance work and alignment of the laser. The operational instructions are to be kept up to date, and stored for reference in the vicinity of the laser setup. In addition they are part of the file maintained by the local supervisor. These instructions must be communicated to new laser workers and maintenance staff by the local supervisor or where appropriate, the laser safety officer. Operational instructions are revised as required by any change in the arrangement or change in equipment use.

Skin protection
When high power lasers are used (class 4) skin burns are a risk. When working with lasers in the UV part of the spectrum, there is a risk of damage to the skin and, upon prolonged exposure, the development of skin cancer. With the use of open-beams additional protection in the form of gloves or clothing and the use of a UV-face shield to protect against reflected UV-radiation may be necessary. The clothing must be capable of withstanding the intensity of the laser beam (fire risk).

Laser safety glasses
Within the laser room laser safety glasses that conform to EN 207 or EN 208 must be present. Glasses purchased before 1995 must be replaced because they do not meet current standards and therefore must be regarded as unsuitable by default (a legal requirement). The glasses must be suitable for protection or attenuation of the laser beam's intensity and wavelengths that are used within the facility. The optical density should be such that the MPE values for the eye are never exceeded in the event of accidental exposure of the eye to the direct or scattered laser beam. Only undamaged protective equipment can be used.

The use of laser safety eyewear is compulsory for all laser workers while working with class 3R, 3B and 4 lasers, when carry out activities described in the RI&E as activities for which safety glasses must be worn. It is compulsory for laser workers to wear safety glasses when carrying out these activities, even if they themselves believe that the exposure risks are limited. If an RI&E is not available for the laser facility all activities involving lasers must be carried out with protective glasses and the laser safety officer should be contacted at the earliest opportunity to arrange for the preparation of an RI&E.

When wearing laser safety glasses is impractical or undesirable, possible alternatives and the risks involved are to be assessed in consultation with the laser safety officer. With regard to the result of this consultation, specific agreements are to be made with regard to the use of laser eye protection. These agreements are recorded in writing as an appendix to the RI&E.

In situations where several laser systems (at different wavelengths) are operated simultaneously, the laser room should be compartmentalised when the laser safety glasses do not offer protection to all wavelengths and/or laser beam powers in use in the room.

Protective housing, interlocks
A protective housing forms a physical barrier that ensures that the laser beam is retained within the limits of the housing, and that the maximum permissible exposure values (MPE) are not exceeded externally. Protective housing should be preferably secured with interlocks, so that the laser cannot be operated when the enclosure is opened or removed. When the requirements for a protective housing are met then the laser is to be considered as a class 1 laser product, and further action is not required. Be aware that if the system is not closed at all times and alignment takes places with an open system for example, additional requirements must be fulfilled as described below.

Laser use in the absence of a protective housing
Where lasers are used without a protective housing, optical tables or similar rigid structures are to be used to enable fixing of setups, and through this the laser beam. In these situations, the laser safety officer must evaluate hazards and the implementation of measures to ensure safe operation, set out in the RI&E.

Working with class 1M, 2, 2M lasers
It is not necessary to consult the laser safety officer when using lasers in these class categories due to the limited power of the lasers. The safe operation of these laser classes falls under the general safety regulations. Measures must be taken to avoid direct observation of the laser beam.
In the case of class 1M and 2M danger to the eye may arise when the beams are viewed using optical aids. When this is the case, calculations must be made of the exposure risks. This requires involvement of the laser safety officer.

Working with class 1C lasers
For laser work with class 1C lasers a RI&E is necessary. It requires involvement of te laser safety officer.

6. Regulations governing working in a laser facility

Clear work regulations and procedures should be drawn up for each laser laboratory. The following list describes the main points that should be adapted or supplemented for each laboratory in local regulations and instructions for new laser workers:

- Whenever and wherever possible, laser beams should run through a beam tube.
- The regulations describe a strict procedure with regard to the carrying out of alignments. Unintentional reflections should be avoided through procedural controls.
- Unnecessary reflection of surfaces should be avoided and parasitic reflections should be blocked by a beam stop.
- Reflecting rings, necklaces, watches etc. are not to be worn in the laser facility especially during alignment operations.
- All optical components, including the laser itself, should be mounted in a fixed position to a table or to another surface, so as to avoid sudden changes in the direction of the laser beam.
- Laser beams must never run at eye level through the room and should preferably run along an optical table at waist height.
- Instructions with regard to passing through the beam level (i.e. bending to pick something of the floor) should be provided.
- If the laser does not run along an optical table, the beam path should be marked clearly, preferably with a beam tube.
- Whenever and wherever possible, beam blockers and black screens should be used to block undesired beam reflections beyond the optical table. A beam dump must be placed at the end of the useful path of the beam in every case.
- Alignment work should preferably be carried out with a reduced-power laser beam , and where possible with an alignment (maximum class 2) laser.
- If possible, alignment work should be carried out in a well-lit area (small eye pupils reduce the risk of eye injury).
- Where possible the laser facility should be lit brightly at all times to minimise pupil dilation.
- When arranging sitting accommodation and computer workplaces within the laser facility, the eyes of the user should be well above laser beam level.
- When a remote entrance door interlock is not used, laser light should definitely not be present in the area around the entrance doors.
- In laser laboratories where work regulations as set out above cannot be implemented, the use of laser safety eyewear should be mandatory at all times when a laser is armed, even when not operating a laser.
- These regulations assume that the lasers that are used carry a CE mark and comply with IEC guidelines and that all the required laser classification labels (symbols) and interlocks are affixed to the equipment. With regard to self-constructed and highly modified systems, the appropriate IEC requirements for the production of lasers should be consulted and a classification made. All non CE-compliant lasers are additionally assessed during the RI&E on hazardous potential (Recent U.S. import is of comparable reliabillity as CE-marked European equipment (Laser Notice 50), Asian import is of major concern).
- A staff member, student or postdoctoral researcher must obtain permission to access facilities in which lasers are in operation. Direct permission from the local laser supervisor is required for personnel who have not received laser safety training or guests to obtain access to a laser facility.
- Access to laser facilities without due reason and the appropriate permissions is forbidden.
- Granting of access to a laser facility to untrained personnel is forbidden except in an

emergency. When access is granted for whatever reason the local laser supervisor must be informed at the earliest possible opportunity.

- Personnel that are not in an appropriate physical or physiological state (for example tired, under the influence of certain medication, alcohol, showing aggressive behaviour) may not be provided access to the laser facilities, irrespective of the degree of experience with respect to lasers and laser safety.

7. Maintenance and third party workers

When maintenance workers of the University or third party contractors perform work in laser laboratories they are also bound by the provisions laid down in this laser safety handbook. This is because the University is even partly responsible if third parties perform work on our sites. These include among others internal maintenance personnel, Facility Management personnel, Real Estate directorate (Vastgoed) and ISSC personnel, housekeeping, window cleaners, installers, but also companies that are installing their laser or providing service or maintenance at it. In fact, anyone without granted access to the laser labs by the local supervisor.

These workers must be instructed with respect to our working procedures, outlining procedures (if applicable) and safe working standards prior to starting to work. Prior to installing a new laser system or maintenance of an existing laser system, the company must provide a RI&E plan to determine whether the work is performed in a safe manner. This is at the discretion of the laser safety officer.

Prior to access a laser facillity, maintenance and third party workers are mandatory to report at the local supervisor of the laser facillity!

8. Regulation and implementation

Monitoring of compliance with the laser safety policy of the University is delegated to the laser safety officers and the laser safety manager.

Audit
A visit of all laser facilities will take place periodically. During this visit the current situation with regard to laser safety, the location of laser systems and concordance with the RI&E and working regulations mentioned therein will be discussed. In addition this will serve as an opportunity for discussion of issues in the area of laser safety.

The visits will be coordinated by the laser safety officer and during the visits he will be accompanied by a local supervisor from a location other than that being inspected. The findings will be recorded in the form of an audit report.

Spot checks
The laser safety officers and laser safety manager are empowered to make unannounced inspections of laser facilities to assess compliance with the use of personal protective equipment and the normal situation in the laser facility and to report on these matters.

9. Incidents

Generally, accidents and incidents must be analyzed and reported via the notification form in order to take correct remedial measures to prevent recurrence of the incident. An accident must be viewed as an opportunity for the organization to optimize measures to prevent recurrence. The actual handling of the incident is described in the Leiden University Regulation "*Regeling melden, analyseren en registreren van arbeidsongevallen, (milieu)incidenten en gevaarlijke situaties*".

Employees and students are obliged to report incidents and accidents by phone (in case of serious accidents) and/or via the notification form.
Under the Working Conditions Act, Leiden University is obliged to report occupational accidents that result in a fatality, permanent injury or hospitalization immediately to the SZW Inspectorate. Reporting to the SZW Inspectorate is done by the central Health, Safety and Environmental department (VGM). For those cases it is vital that the incident could be reconstructed by the SZW Inspectorate even if it implies that the accident location must be sealed pending the investigation.

Reporting laser incidents
All laser incidents must be reported as soon as possible to the local supervisor and the laser safety officer. This can be achieved using the *notification form for unsafe situations, accidents and (needlestick) injuries* on the Internet site of the university.

In case of a serious laser accident (with injury, fire etc.), use the internal alarm number and also call your LSO. The LSO must inform the laser safety manager within 24 hours. The laser safety manager decides if the accident must be reported to the SZW Inspectorate.
Also fill out the *notification form for unsafe situations, accidents and (needlestick) injuries* on the Internet site of the university.

Handling of a laser incident
When necessary, incidents are investigated by the laser safety officer and laser safety manager. It is important that reconstruction remains possible even if its implies that it is not allowed to use the laser system. If possible, take pictures of the situation directly after the incident.

Appendix 1. Laser classification

Class 1 (considered safe)
Class one lasers are safe both with respect to eyes and skin under normal use. The maximum power output of a class 1 laser is 0.5 µW. This classification can be applied to applications using visible as well as invisible lasers. Class 1 laser products may contain a high power laser system (for example, a class 3B laser used in a confocal microscope), but the construction prevents the power during use from ever exceeding 1 AEL. Note that class 1 lasers are not inherently safe.

Class 1M (under normal situations considered safe)
This classification applies only to wavelengths between 302.5 and 4000 nm. Class 1M lasers cannot exceed the AEL of class 1 lasers, but the power of the beam can be very high. The classification is based on the proportion of the beam that can fall on the eye. Laser beams in class 1M are divergent (the diameter of the beam increases rapidly with distance from the source) or have a large diameter when collimated. Therefore lasers in this class are not safe with regard to skin or eye exposure when used with optical elements, for example, a lens.

Class 1C (under foreseen use conditions considered safe)
This laser class is introduced by NEN-EN 60825-1:2014 in August 2014. Class 1C can be put to lasers with a direct contact-application to skin or non-eye tissue. However the output of these lasers can be of class 3R, 3B or 4, they are technically protected in such way, that during use no exceeding of the maximum permissible exposure is possible.
Example: opto-acoustic imaging.

Class 2 (low power)
Class 2 is only applicable to lasers in the visible region (400-700 nm). The lasers in this class can be either continuous or pulsed. The eyes are protected by the blink reflex. The maximum exposure by the eye to the beam is assumed to be 0.25 s (the time necessary for the head to move or to blink). The maximum power of a class 2 laser is 1 mW.

Class 2M (low risk, under normal conditions)
Class 2M lasers cannot exceed the AEL for class 2 lasers, but the power of the beam can be much higher. The classification is based on the proportion of the beam that can fall on the eye. Laser beams in class 2M are divergent (the diameter of the beam increases rapidly with distance from the source) or have a large diameter when collimated. Therefore lasers in this class are not safe with regard to skin or eye exposure when used with optical elements, for example, a lens.

Class 3R (intermediate power)
Class 3R lasers operate in the wavelength region 302,5 nm- 1 mm. Direct exposure to the beam is dangerous but less so that for class 3B laser products. The AEL is less than 5x the AEL-value for class 1 and 2 (400 -700 nm) lasers. The maximum power is 5 mW.

Class 3B (intermediate / high power)
Class 3B is applicable to visible as well as invisible radiation. Direct observation of the beam is always dangerous. Diffuse reflections are normally eye-safe, provided that the eye is no closer than 13 cm from the reflecting surface and the exposure is less than 10 seconds. The maximum power of a class 3B laser is 500 mW.

Class 4 (high power)
Class 4 lasers are dangerous. Both direct observation of the beam as well as reflected beam is always dangerous and the probability of injury as a result is high. Damage (fire) to the facilities is also a serious hazard. Diffuse reflections can be dangerous and can result in eye and skin injury or the ignition of flammable material. **Class 4 lasers must always be treated with caution.**

N.B. The power limits apply to point sources only and not for so called “extended sources”. In addition they are only applicable to the indicated spectral region. Further information regarding the classification of apparatus that are operational in other wavelength ranges can be found in tables 4 to 9 of NEN-EN-IEC 60825-1:2007.

Appendix 2. Basic facility standards for laser facillities

The design requirements described here apply to new laser laboratory facilities or for laser laboratory facilities wherein substantial remodelling is undertaken. Existing laser laboratories fall under a special category, in which a transitional arrangement will be applied where structural changes will follow from established RI&E laser safety assessment of the system. The basic design requirements contribute to establish uniformity in the design of laser laboratories througout LU, which satisfies legislative requirements for the use of class 3B and 4 lasers. In addition, the installation of an interlock systems should provide optimal flexibility for users. Infrastructural changes that result from changes in the use and positioning of systems should as a result be minimised.

Engineering controls:

- Primary shielding is realized from an architectural unity of walls and ceilings with a demonstrably sufficient radiation protection where windows are not allowed,
- There are no reflective surfaces on installation parts accessible to the beam as ducts and air ducts, if necessary, it should be matted,
- Warning signs on the door (yellow triangle with starburst logo), where these are not provided already by the 'laser on' light,
- Pass or button code door access system,
- Interlocks switches must be present on access and emergency doors,
- The entrance door must be fully closable and must not contain glass panels,
- Second door or intermediate space behind the entrance door; an emergency power down button and warning light indicating when a laser beam is generated in the room (connected to the interlock system),
- Emergency power down button at logical points in the laser room (in rooms with several optical tables the emergency stop system must be easily expandable),
- The room is preferably not equipped with a sprinkler system,
- The room and the door space must be equipped with a CO2-extinguisher,
- Audible slow- whoop in the laser room, or if not replaced by optical alert signal in case of evacuation of the building,
- The interlock system must, as a minimum, be able to control/respond to the following parameters (there are commercial systems available for this purpose):
    - 'laser on' signal at the time that the laser systems power supply is switched on,
    - Warning light turned on at the moment that the laser power supply is turned on,
    - Laser switches to safe mode when the interlock switch on entrance or exit doors is triggered (safe mode does not necessarily mean power off, in appropriate cases, e.g. cooling or ventilation remain in operation),
    - Laser energy off when the emergency button at the break-out-box is pressed,
    - Full reset mode, laser can only be restarted after a set procedure has been followed, in which interlocks are reset (short circuits are possible where interlocks are not in use),
    - The system should be preferably extendable to connect with gas detection systems, local evacuation and fire alarms

N.B. Prior to adopting the final version of plans for a facility the laser safety officer (AMD) or the laser safety manager (VGM) should be consulted!