Curtin University

Laser Safety Guidelines

Health and Safety

CONTENTS

1. INTRODUCTION

1.1. Purpose

This is a draft for potential laser guidelines for Curtin University. Over the last couple of years it has become apparent that there is still some confusion as to the requirements for laser safety. Some of this stems from the fact that much laser safety comes in the form of Standards where it is possible to achieve similar outcomes via different methods. Having options is advantageous as it is not always possible to conduct research by imposing the same set of controls in all circumstances. As an institution we must demonstrate that we are striving for best practice, while at the same time allowing sufficient risk assessed flexibility to enable pioneering research.

The Radiation Safety Act 1975 and associated regulations impose a number of restrictions for the use of high powered lasers. All such instruments must be registered and most can only be used under the supervision of a suitably qualified individual with an appropriate WA government issued licence. Furthermore, national standards are established for the use of both high and low powered lasers, some of which have been adopted by legislation.

The purpose of these guidelines is to provide guidance to University workers, students and visitors for the safe use of lasers and laser systems. The guidelines should be read with reference to the Radiation Safety Act 1975 and associated regulations and the Standards AS/NZS 2211 and AS/NZS IEC 60825.

1.2. Scope & structure

These guidelines will be applicable to all Curtin University campuses and will apply to all classes of laser. This guide is structured as follows: Section 2 is related to project authorisation for the use of lasers in teaching and research. Section 3 provides information about laser equipment and PPE. Section 4 lists the requirements for different types of laser facilities. Section 5 is related to work procedures and other documentation involving lasers.

1.3. Definitions

1.3.1.MPE

The Maximum Permissible Exposure (MPE) is the highest power or energy density of laser radiation that an individual can be exposed to without suffering adverse effects. The MPE is dependent on the wavelength and exposure time, so the Standard must be checked to find the appropriate level.

1.3.2.Open beam

An open beam laser is one where it is possible:

i) to inadvertently access the primary laser beam with any body part (class 4 lasers only);
ii) for intra-beam viewing of the laser; or
iii) to introduce a single flat reflecting object to the primary beam to cause it to be directed to an area outside the protective barrier of the laser;

without first disabling an interlock or using tools to dismantle the protective housing.

1.3.3.RSO

The Radiation Safety Officer for the University.

1.3.4.Work area

Work Area, for the purpose of this document, is a broad term that can cover a School, Institute, Discipline, Centre, geographical location or any other collection of units/locations as agreed by the Head(s) of School with responsibility for resources included therein.

1.4. Authorised personnel and responsibilities

There are various personnel across the University with responsibilities related to lasers, including the University RSO, the Radiation Safety Committee, local Radiation Safety Supervisors and licence holders. In addition, all staff and students must adhere to the requirements and report any safety, health or security concerns. A full description of responsibilities related to radiation safety can be found in the Radiation Safety Manual.

2. RESEARCH AND TEACHING INVOLVING LASERS

Before starting any work involving high powered lasers you must have approval from the University RSO or Radiation Safety Committee. If you are a student and your Supervisor already has approval to cover your work, they can apply for an amendment to add your name to their project. If not, you must start a new application.

A radiation project application or amendment must be submitted before any new purchase of a class 3B or 4 laser because some facilities may require modifications prior to the use of the equipment. The local Radiation Safety Supervisor (RSS) can provide advice related to current facilities in their area. Where possible the laser should have an input/output connector so that interlocks can be connected if required.

Final disposal of any laser product must be carried out by a licenced service person by removing the power supply (by severing the cord) and removing the critical optical components and the amplifying medium to render the equipment inoperable.

2.1. Approval for class 3B or 4 lasers

All teaching or research involving class 3B or 4 lasers must be approved prior to the commencement of work and must have a radiation licence holder taking responsibility for the day-to-day safety aspects of the equipment. Details on how to obtain project approval are described in section 5.1.

The application or any amendments will be reviewed by the:

- Chief investigator for the project
- Radiation licence holder for the equipment
- Local Radiation Safety Supervisor (RSS) (or, if this role is vacant, the Head of School)

After review, the University RSO will triage your application as either Low-Risk or High-Risk. Low-Risk applications will be processed by the University RSO, whereas High-Risk applications will be assessed by the Radiation Safety Committee.

2.2. Open beam research with class 3B or 4 lasers

Where possible the laser should be enclosed in its own protective housing as described in section 4.1. For research projects, where complete enclosure of the laser prevents or significantly hampers effective research, a controlled area for open beam laser work can be established as described in section 4.2.

Where open beam laser work is being conducted it is necessary for all laser users to have their own laser licence, or work under the immediate and direct supervision of another laser licence holder at all times while in the laser laboratory. (For comparison, if the laser is in its own enclosure and can't be accessed at full power, then there only needs to be one laser licence holder responsible for the safety of that laser. Other trained users can operate the laser without the licence holder present in the laboratory). The risk assessment must provide reasons why it is necessary to adopt open beam laser work as opposed to adopting a full enclosure.

2.3. Class 3R lasers

It is not necessary to seek project approval or hold a licence to operate a class 3R laser. However, operators of class 3R lasers must have safe work procedures (SWP) and risk assessments for their work. The SWP and risk assessment must explicitly state the Nominal Ocular Hazard Distance (NOHD), which can be calculated from Equation 1. The SWP and risk

assessment must detail how users will control the area within the NOHD to ensure the safety of themselves and/or members of the public.

The MPE is in units of W m^{-2} and is dependent on the properties of the laser and can be found in tables A.1 to A.5 of AS/NZS IEC 60825.1:2014. Radiation power is in units of W, initial beam diameter is in m, and beam divergence is in radians.

$$\mathrm{NOHD} = \frac{\sqrt{\frac{4 \times \text{radiant power}}{\pi \times \mathrm{MPE}}} - \text{initial beam diameter}}{\text{beam divergence}}$$

Equation 1. Nominal Ocular Hazard Distance (NOHD).

2.4. Training

Other persons working under the supervision of a licence holder must have a level of training appropriate to the work they are conducting. This training can be one of the WA Regulator accredited courses or an equivalent level of training. The licence holder must retain documentary evidence of the training of each user under his/her supervision. A copy of the training documentation must be attached to the project approval in InfoEd.

For projects involving lasers with power below class 3B it is not necessary for anyone to have a licence. If the equipment is used in accordance with the manufacturer's instructions then it is sufficient to ensure users read the safe working procedures and risk assessments for the apparatus and undergo training on its use. The supervisor must retain documentary evidence of the training of each user under his/her supervision.

3. OTHER EQUIPMENT

3.1. Embedded lasers

If a class 3B or 4 laser is embedded in the instrument by a manufacturer prior to acquisition by Curtin, such that during normal operation the beam and all components of the laser are only accessible by using tools to dismantle the equipment, then the laser can be categorised as a class 1 embedded product. As such, it would not need to be registered or operated by a licence holder. Examples would include DVD writers, some laser ablation mass spectrometers and some confocal microscopes.

At Curtin the following equipment will automatically be considered 'embedded lasers' if it is acquired from a manufacturer and used in accordance with those manufacturer's instructions:

- CD, DVD, Blue Ray or other optical disk players and writers
- Printers and copiers

For other equipment, the determination as to whether a laser meets the class 1 embedded criteria (according to the Standard), should be made by the University RSO.

If it is possible to remove part of the protective housing without tools and access the beam or remove any component of the laser, the instrument will need to be registered. Furthermore, if the protective housing is removed and a user can be exposed to an accessible emission limit equivalent to a class 3B or 4 laser then the operators must have, or work under the supervision of someone with, a licence.

If an embedded laser requires servicing or maintenance such that service personnel could potentially be exposed to an AEL equivalent to that of a class 3B or 4 laser, then the service or maintenance should be carried out in a laser facility that meets the requirements for those classes of lasers (see section 4).

3.2. Laser pointers

It is an offence under the WA Radiation Safety Act to manufacture, sell, possess or use a laser pointer with a classification exceeding Class 2 (1mW maximum output), except where Government approval has been obtained for a laser with greater power. There may also be instances where a laser pointer with power greater than that of a Class 2 can be used for scientific research, although work with those lasers will be subject to approval as described under Section 2.

Laser pointers are effective tools when used properly. The following considerations should be observed when using laser pointers for general use:

- Use only laser pointers with AS/NZS 2211 classification Class 1 or Class 2 (1 mW max output)
- Class 2 lasers are labelled 'Caution: Laser Radiation'
- Never look directly into the laser beam.
- Never point a laser beam at a person.
- Do not aim the laser at reflective surfaces.
- Do not allow children to use laser pointers.

3.3. PPE

Laser eye protection must be worn for any open beam work with Class 3B or Class 4 lasers. The laser eye protection must be of a kind that is appropriate for the wavelength(s) and maximum intensity of the laser(s) being used and suitable for the type of work being done. The eyewear must have its optical density and the wavelength protection region clearly stated by the manufacturer somewhere on the eyewear itself. Eyewear must be located in a place that is accessible to users and where there is no possibility of exposure to the beam.

For alignment purposes, where a low powered alignment laser is not available, the use of laser viewing cards is the recommended method. The use of alignment eyewear is not recommended and can only be used when it is shown that viewing cards are not adequate. The risk assessment should document the reasoning for the use of alignment eyewear.

4. LASER FACILITY REQUIREMENTS FOR CLASS 3B AND 4

Laser facility requirements are given in both legislation and Australian Standards. As such, there may be numerous ways of meeting these requirements so the nature of the research activities would have to be considered when designing the facility. These laws and Standards apply to all class 3B and 4 lasers, except when it is categorised as an embedded laser (section 3.1).

Below are 3 examples of laser facility designs that may be suitable for research work. These examples should be referred to in conjunction with the legislation in Schedule XIII (class 3B lasers – see Appendix I) and Schedule XIV (class 4 lasers – see Appendix II). The following is a summary of the main elements of the legislation and Standards. As such, it should not be considered an exhaustive list of requirements but rather a guide to the main considerations only. Further clarification can be provided by the University RSO.

For all facilities, every laser and laser laboratory must have a warning sign that meets the requirements of AS/NZS IEC 60825.1:2014. These labels must be permanently fixed and positioned such that they can be read without exposure to laser radiation. All labels must have text and borders in black on a yellow background.

4.1. A laser enclosure

- Usually the simplest and most cost effective design is to have an enclosure around the laser that encompasses the entire beam to make it impossible either for any accidental reflections or for anyone to make physical contact with the beam.
- There must be either a failsafe interlock that either cuts the power to the laser or reduces its power (by means of a shutter or filter) to that of a class 2 or below when the enclosure is opened, or the enclosure must be constructed in such a way that during normal operation the beam and all components of the laser are only accessible by using tools to dismantle the equipment
- The enclosure must be constructed of a material that prevents intrabeam viewing.
- There must be a warning light on the outside of the enclosure showing when the laser is on.
- Alignments must be conducted either remotely, or if access to the enclosure is required, the alignment must be done with the use of a second low powered (class 2 or below) laser or a filter in place that reduces the power of the main laser to that of a class 2 or below.
- Where it is possible to access the beam in high powered mode (for example during servicing or maintenance), the work must be conducted in a controlled area and PPE appropriate to the power and wavelength must be available.

4.2. Controlled area with a door interlock

- When the beam is not entirely enclosed, and personnel are required to work in the vicinity of the laser, it is necessary to have a controlled area (i.e. a dedicated room) with non-reflecting surfaces, adequate lighting and blocked windows.
- Risk assessments should include an explanation as to why the work cannot practicably be achieved by adopting the laser enclosure method above.
- A failsafe interlock must be fitted to the door of the controlled area, which must either cut the power to the laser or reduce its power (by means of a shutter or filter) to that of a class 2 or below when the door is opened. An example of an acceptable interlock protocol is provided in section 4.2.1.
- If continuous operation of the laser is required, a keypad can be installed so that a laser licence holder can input the pin code to enter the controlled area without activating the interlock.
- The controlled area must have the means to restrict access to authorised personnel only. However, in an emergency it must be possible for personnel to rapidly enter or exit the area. The interlock should be triggered when emergency personnel enter the controlled area.
- The door control system must be configured using the Universities Access Control System and controlled by the Security Management System.
- There must be the means to cut the power to the laser from inside the controlled area via an emergency stop button.
- PPE appropriate to the power and wavelength of the laser must be available and located outside the controlled area so that personnel can don the PPE prior to entry.
- There must be warning lights both inside and just outside the controlled area showing when the laser is on. The warning light inside must be visible through the protective eyewear.
- The beam should be below eye-level and reasonably practicable engineering controls should be implemented to protect personnel from ocular (class 3B and 4) and skin (class 4) exposure (for example, confining the beam to a benchtop within beam guides and guards).
- Reflective surfaces within the controlled area must be removed, permanently covered or painted with a matte paint.
- There must be a fire resistant beam stop to terminate the beam.
- Shutters at the laser aperture can be used if required and connected to the interlock.

4.2.1. Example of an acceptable door interlock protocol

When the laser is initially OFF:

- Door is set to SECURE – staff students must swipe to enter the room.

When the laser is switched ON:

- Activates the LASER ON LED sign outside the room.
- Door goes from SECURE to SECURE and 6 PIN.

- Entering the room can be achieved by swiping at the card reader and entering the user's unique 6 digit pin. (Only laser licence holders should have a pin to open the door with the laser on). (Allows 20 seconds to enter and close the door)
- Entering the room by swiping without the 6 digit pin should be possible for emergency situations. However, under such circumstances the laser must power down.
- To exit the room an EXIT BUTTON is pushed to exit safely without powering down the laser. (Allows 20 seconds to exit and close the door).
- Exiting the room without pressing the EXIT BUTTON will power down the laser.
- Forcing the door open from the outside will power down the laser.
- Holding the door open for more than 20 seconds will power down the laser.
- Contacting the Safer Community Team and asking them to put the door back to SECURE mode will power down the laser.

When the interlock powers down the laser or the laser is switched OFF:

- LASER ON LED sign turns off
- Door returns to SECURE mode

4.3. Temporary controlled area

- When the laser is normally operated within a laser enclosure it is not necessary to utilize a controlled area. However, it may sometimes be necessary to open the enclosure, for example during a service. On these occasions it is necessary to ensure the following matters are addressed.
- A risk assessment should be created detailing the procedures to be adopted and the controls put in place for the duration of the service. This risk assessment should be reviewed and signed by the licence holder responsible for the laser and the University RSO.
- A temporary controlled area must be established that is under the immediate supervision of the licence holder responsible for the laser in question for the duration of the procedure.
- Access to the area must be temporarily restricted so that only the laser licence holder has swipe card access to the room. The licence holder can authorise others to enter, but must remain in the area for the full duration of the procedure.
- Signage must be displayed outside the controlled area warning others of the nature of the work and the hazard, and a temporary physical warning (e.g. traffic cone or temporary barrier) must be placed just outside the door.
- Any windows or other potential gaps to public areas must be sealed for the duration of the procedure.
- PPE appropriate to the power and wavelength of the laser must be available and worn by all occupants for the duration of the procedure.

4.4. Other designs

It may be possible to construct laser facilities with designs other than those specified above, but which remain consistent with the Australian Standards. For any new design not mentioned above the University RSO must provide approval before any designs are finalised.

5. DOCUMENTATION

5.1. Project approval

To apply for project approval, log into InfoEd using your Curtin credentials and create a new record. User guides are available to assist staff at in the research training page of the staff portal. Students can access the user guides via the student website. Projects that meet all the necessary requirements will be given ongoing approval subject to annual reporting and submission of amendment requests when details of the project change.

5.2. Risk assessment

All operators undertaking experiments involving class 2, 3R, 3B or 4 lasers must undertake a risk assessment prior to starting the work. For projects involving class 3B or 4 lasers the risk assessment must be approved by the laser licence holder. Risk assessments for class 2 or 3R lasers can be approved by any staff member with knowledge of the work practices/procedures.

The hierarchy of safety controls has the following types of controls in order of priority: elimination, substitution, isolation, engineering, administrative and PPE. If elimination (not using the lasers) is not possible, the next control would be to substitute the laser i.e. use a lower power laser if the research outcomes can still be met. The next control is to isolate the laser i.e. house the laser if a separate area and control the laser from outside this area. So, if it is possible for researchers to reasonably achieve their research outcomes by operating the laser from outside the controlled area then we must do this.

If it can be demonstrated that operating from outside the controlled area is not reasonably practicable, the next step is to explore engineering controls within the controlled area. These engineering controls should be a barrier between the beam (including beams incidentally reflected from a single flat surface) and the occupants of the area. Once the above controls are in place it is also necessary to adopt administrative (i.e. training and safe working rules) and PPE controls. The risk assessment should show that the controls mitigate the risk of ocular exposure above the MPE. For class 4 lasers it is also necessary to demonstrate that any incidental reflections from a single flat surface would not exceed the MPE for skin.

Where Engineering controls described above are not reasonably practicable, administrative and PPE controls must be used. Where only administrative and PPE controls are used to mitigate the risk of exposure from incidental reflections from a single flat surface, all occupants of the controlled area must either possess a current laser licence or be working under the immediate personal supervision of someone with a current laser licence.

5.3. Safe work procedures

Safe work procedures must be created for all class 3R, 3B and 4 lasers. These safe work procedures for class 3B and 4 lasers must be submitted as part of the project approval process and must be approved by the University RSO or Radiation Safety Committee. Safe work procedures for class 3R lasers can be approved by the local Radiation Safety Supervisor. For class 1 embedded lasers a Safe Work Procedure must also include procedures for service and/or maintenance if that work is to be carried out on campus. Templates of safe work procedures can be found on the research website in the staff portal.

REFERENCES

These guidelines are informed by the following:

a) AS/NZS IEC 60825.1:2014. Safety of laser products - Equipment classification and requirements.
b) AS/NZS 2211.1:2004. Safety of laser products - Equipment classification, requirements and user's guide. Note this standard was superseded by AS/NZS IEC 60825, but is still referred to in the WA legislation.
c) Radiation Safety Act 1975
d) Radiation Safety (General) Regulations 1983

APPENDIX I

Radiation Safety (General) Regulations 1983
(Regulation 54)
SCHEDULE XIII

REQUIREMENTS TO BE COMPLIED WITH IN RESPECT OF PREMISES IN WHICH REGULATED CLASS 3B LASERS ARE OPERATED OR USED

1. Such beam stops, beam enlarging systems, shutters or other safety devices as the Council from time to time directs shall be incorporated in the laser or its system.

2. The beam of the laser shall be —

   (a) contained within enclosures; or

   (b) terminated at the end of the useful beam path by a beam trap or, in the case of a laser which is an infrared laser, by a highly absorbent backstop.

3. In the case of a laser which is an ultraviolet laser, such special precautions as the Council from time to time directs for reducing radiation or preventing undesirable chemical reactions shall be taken.

4. Any optical system used for viewing in connection with the laser shall be provided with an interlock or filter to reduce ocular irradiation to a safe level.

5. The laser or its laser system shall be provided with a master switch which, when a key, magnetic card, cipher combination or other similar device is removed therefrom, makes it impossible to operate or use the laser or its laser system.

6. Labels shall be affixed to the laser or to the protective housing of its laser system in accordance with the requirements of the laser safety standard.

7. Approved instructions shall be issued to all persons operating or using the laser.

8. Persons, other than persons authorised by the person in whose name the premises concerned are registered to operate or use the laser or its laser system, shall not operate or use the laser or its laser system.

9. Whenever persons operating or using the laser or its laser system are exposed to potentially hazardous laser radiation, those persons shall be provided with protective eye-wear in accordance with Section 10.8 of the laser safety standard.

10. The laser or its laser system shall be operated or used only in a controlled area.

11. Bench and wall surfaces in the controlled area referred to in item 10 shall be painted with matt paints of approved colours so that those surfaces are not highly reflective to the radiation of the laser.

12. Areas which are exposed to reflections from an infrared laser or its laser system shall be protected by screening the beam or target area concerned with infrared absorbent material.

13. The illuminance level in the controlled area referred to in item 10 shall, unless the Council otherwise directs, be not less than 350 lux.

14. Persons other than those operating or using the laser or its laser system shall not enter the controlled area referred to in item 10 unless they have the permission of the person in whose name the premises concerned are registered to do so and take such protective measures as he directs.

15. There shall be displayed —

(a) in conspicuous locations inside and outside the controlled area referred to in item 10; and

(b) at all entrances giving access to the controlled area; and

(c) in a prominent position near the laser,

area warning signs in accordance with Section 10.5 of the laser safety standard.

16. Persons operating or using the laser system are to undergo eye examinations in accordance with section 10.11 of the laser safety standard.

APPENDIX II

Radiation Safety (General) Regulations 1983
(Regulation 55)
SCHEDULE XIV

REQUIREMENTS TO BE COMPLIED WITH IN RESPECT OF PREMISES IN WHICH CLASS 4 LASERS ARE OPERATED OR USED

1. The entire beam path of the laser shall be enclosed and that enclosure shall be equipped with interlocks in accordance with Section 4.3 of the laser safety standard in order to prevent the operation or use of the laser if that enclosure is not properly installed.

2. The laser or its laser system shall be provided with a master switch which, when a key, magnetic card, cipher combination or other similar device is removed makes it impossible to operate the laser or its laser system.

3. The beam of the laser or its laser system shall be terminated in an absorbent fire resistant material, which shall be inspected periodically for signs of deterioration.

4. If the laser or its laser system is operated or used without its entire beam path and interaction site enclosed, that operation or use shall take place in a controlled area which is permanently isolated from other areas within the premises concerned.

5. Except in medical laser installations, safety latches or interlocks designed —

   (a) to prevent uncontrolled entry into; and

   (b) to enable rapid exit from; and

   (c) to enable rapid entry in an emergency into,

   the controlled area referred to in item 4 shall be installed.

6. It shall be possible temporarily to override entrance safety switches to permit persons to operate or use the laser or its laser system whilst that operation or use is continuous.

7. In the case of a pulsed laser, power supplies thereto shall be as far therefrom as possible.

8. In industrial laser installations, the laser or its laser system shall be —

   (a) operated or used; and

   (b) monitored by means of closed circuit television or through a viewing window of approved design,

   from a position outside the controlled area referred to in item 4.

9. A control switch shall be situated in the controlled area referred to in item 4 for the purpose of switching off the laser in the event of an emergency.

10. Surfaces within the controlled area referred to in item 4 must be rendered non-reflective by means of approved materials to reduce the possibility of hazardous diffuse reflections.

11. In the case of an infrared laser, surfaces within the controlled area referred to in item 4 which are exposed to reflections from that laser shall be protected by screening with approved fire-resistant material close to the reflecting source of that laser.

[12, 13. Deleted]

14. Approved ear protection shall be provided for persons operating or using the laser during noisy applications thereof.

15. The requirements of Part IV shall be complied with in respect of any ionising radiation produced by the laser.

16. High pressure arc lamps and filament lamps in the laser or its laser system shall be enclosed in housings capable of withstanding the maximum explosive pressures resulting from the disintegration of those lamps.

17. The target of the laser and elements of its optical train which are liable to shatter during the operation or use of the laser shall be enclosed in housings or otherwise protected to prevent injury as a result of any such shattering to persons operating, using or observing the laser.

18. Approved shielding shall be provided in respect of ultraviolet, visible and infrared collateral radiation from a laser discharge tube, optical pump source or other part of the laser or its laser system.

[19.deleted]

20. The illuminance level in the controlled area referred to in item 4 shall be not less than 350 lux at all working sites during the operation or use of the laser.

21. An alarm system, consisting of lights visible through protective eyewear, shall be used to give warning of the operation or use of the laser.

22. Area warning signs complying with Section 10.5 of the laser safety standard shall be displayed at the entrance to the controlled area referred to in item 4.

23. All persons having access to the controlled area referred to in item 4 shall be authorised to do so by or on behalf of the person in whose name the premises concerned are registered.

24. Persons operating or using the laser system are to undergo eye examinations in accordance with section 10.11 of the laser safety standard.