Laser Safety Guide

1. Purpose

This document provides guidance on the safe use of laser products in research, teaching and/or event activities conducted at the University of Newcastle. A laser product may consist of a single laser with or without a separate power supply or may incorporate one or more lasers in a complex optical, electrical, or mechanical system.

2. Scope

This guideline applies to all laser product users, including staff, students, visitors (volunteers, contractors etc), for activities conducted by the University of Newcastle both on and off-campus. The guideline is based on Australia & New Zealand Laser Safety standards and applicable to safety of laser products emitting laser radiation in the wavelength range 180 nm to 1 mm that include visible and invisible.
A list of standards is provided in section 9 and list of Definitions in section 10. This document provides a brief summary, for comprehensive guidance, please refer to the standards.

3. Laser Classification

The AS/NZS IEC 60825.1:2014 Laser Product Safety standard classifies lasers into four classes and few subclasses based on accessible emission level determined on combination of the laser output power(s) and wavelength(s) and comparison with the accessible emission limit (AEL) associated with each class. These classifications are determined by the potential hazard of accessible laser radiation in respect to human eyes and skin and does not relate to other potential hazards such as electrical, mechanical or chemical hazards, or hazards from secondary optical radiation. Classification is required by law and any laser product should have a label listing the Class. Any laser/laser system built or modified and operated by members of the University of Newcastle must be classified and the classification checked and confirmed by the LSO.

Table 1: Laser Classes

	Hazard summary and short description	**Approximate power limits***
Class 1	No precautions required. This group is limited to very low power semi-conductors or totally enclosed laser systems where human access to higher	39 µW to 390 µW (depending on wavelength)

	levels of internal laser radiation is not possible during normal operation.	
Class 1M	Safe with no viewing aids**. The permitted accessible emission limits exceed Class 1, but it cannot cause harmful levels of exposure to the unaided eye. Avoid the use of magnifying viewing aids	
Class 1C	Includes any laser product which is designed explicitly for contact application to the skin or non-ocular tissue where: During operation ocular hazard is prevented by engineering means, i.e. the accessible emission is stopped or reduced to below the AEL of Class 1 when the laser/applicator is removed from contact with the skin or non-ocular tissue; During operation and when in contact with skin or non-ocular tissue, irradiance or radiant exposure levels may exceed the skin MPE as necessary for the intended treatment procedure.	
Class 2	Visible wavelength only. Safe for the skin and safe for the eyes. Laser products emitting low-levels of visible radiation (wavelength 400 m to 700 nm). Eye protection is normally ensured by natural aversion responses to bright light (the blink reflex 0.25 s). Eye exposure caused by deliberately staring into the beam can damage eyes.	1 mW
Class 2M	Visible wavelength only. Safe with no viewing aids*. Laser products emitting levels of visible radiation that exceed the permitted accessible emission limits for Class 2 but safe with aversion response (0.25 s). Avoid the use of magnifying viewing aids*	
Class 3R	Low risk in the visible range and not viewing aids. Not safe outside visible. Cannot cause serious skin injury. Laser products having a level of accessible emission up to five times the limits for Class 1 (if invisible) or Class 2 (if visible). Low risk in the visible range within the blink reflex and not viewing aids*. Not safe outside visible.	5 mW
Class 3B	Unsafe for eyes and generally safe for skin	0.5 W

	Laser products having a level of accessible emission, which can be harmful to the eyes, whether viewing aids* are used or not. It can also be harmful to the skin at output levels approaching the upper limit of this class. Prevent eye (and in some cases skin) exposure to the beam. Guard against unintentional beam reflections.	
Class 4	Unsafe for eyes and unsafe for skin Laser products having a level of accessible emission, which can be harmful to both the eyes and the skin. Diffuse reflections of the laser radiation may also be hazardous. The laser emission can also be sufficient to ignite material, on which it impinges, and to generate harmful radiation or fume hazards by interaction with target materials. Prevent eye and skin exposure to the beam, and to diffuse reflections (scattering) of the beam. Protect against beam interaction hazards such as fire and fume.	500mW-1.5W
* Approximate power limits for visible CW light		
** Viewing aid instruments include binoculars, telescopes, microscopes and magnifying lenses, but not spectacles or contact lenses. Avoid placing optical devices in the emitted beam that could cause the concentration of the laser radiation to be increased. Do not direct the beam into areas where other people may be present if there is a likelihood of the people in those areas using telescopes or binoculars to look directly into the beam.		

4. Risk assessment

There are many potential hazards arise with using laser products due to the wide possible ranges of laser beam characteristics (the wavelength, energy content and pulse parameters). The hazards include damage to the human eye and skin, and associated electrical, chemical and miscellaneous hazards such as fire, noise, toxic, cryogenic, incidental X-rays, etc.

4.1. Any work that involves the installation, operation, maintenance, service or disposal of laser products can result in exposure to laser radiation and other hazards associated with using lasers. Laser radiation is a major hazard associated with laser use. Please view a summary of hazards (Appendix 1) as listed in the AS/NZS IEC 608251.2014 or consult the standard itself.

4.2. The supervisor, laboratory manager or equivalent team lead must complete a risk assessment before commencing use of a laser product. The hazard identification and control process should be conducted in consultation with the local safety personnel, LSO and/or the Health and Safety team. The hierarchy of controls must be used to mitigate the risks as far as reasonably practicable. HSG 3.1: Health and Safety Risk Management

4.3. The risk assessment should assess the risks associated with the following hazards including but not limited to:

- direct exposure of the eyes or skin to a laser beam;
- other hazards incidental to laser operation;
- electrical hazards;
- vaporised target material and reaction products such as fume;
- noise;
- cryogenic coolants;
- heat and cold;
- fire and explosion;
- harmful substances;
- identify appropriate control measures as necessary.

4.4. Risk assessments must be reviewed regularly and when;

- significant changes (e.g., increasing or decreasing power, removing or bypassing interlock) are made to the laser equipment;
- when there is an injury or incident as a result of laser exposure
- two years have elapsed since the previous review

5. Controls

Controls must be implemented to ensure that individuals are not adversely affected by laser use.

Hierarchy of control measures are elimination, substitution, isolation, engineering controls, administrative controls, and personal protective equipment (PPE). If the use of the laser cannot be eliminated or substituted with an alternative, then engineering controls are the most important control.

5.1. Engineering Controls

The following should be considered:

- A protective enclosure/housing is recommended for all lasers that are in operation, to minimise the risk of accidental exposure. If using a laser without an enclosure/housing, the operator in charge must use appropriately designed beam stops to ensure that the laser beam remains confined to the experimental area at all times.
- The beam should remain within the bench or established laser controlled area and where feasible a fail-safe should be in place. The laser must be operated at the minimum power necessary for any practice.
- Incorporate beam stops and/or attenuators (example ND filter) to prevent human access to laser radiation in excess of the AEL for Class 1M or Class 2M as applicable.
- Use the laser on a lower power or lower-class laser when possible and particularly during alignment procedures.

- Interlocks are incorporated into some laser products especially Class 3B and Class 4 to shut off the laser automatically or insert a mechanical shutter that blocks the beam when the interlock is triggered.
- Each Class 3B and Class 4 laser will have incorporated key-operated master control with a removable key. Remove the key to control access to the laser
- Emergency shut off button is available.
- Minimise reflective surfaces when working with lasers: eg remove jewellery, close glass doors and windows.

5.2. Administrative Controls and Local rules and procedures

There are different levels of administrative control depending on the class of laser product. Use the Flow chart to determine the necessary administrative controls required by the University before commencing work. This will help determine if registration and/or approval is needed by the University's Chemical and Radiation Technical Committee (CRTC).

(i) Laser Registration

- To manage the risks posed by lasers or laser devices, The University health and safety team must keep a register of Class 3R, Class 3B, Class 4 lasers and Class 1 laser product with embedded Class 3B and /or Class 4 lasers used on its premises.
- All university divisions including research institutes, centres and College/schools which operate Class 3R, Class 3B, Class 4 lasers and/or Class 1 laser product with embedded Class 3B and /or Class 4 lasers must ensure these are registered with the University. To register lasers, use the Laser Equipment Registration Form.
- A completed copy of the registration form for each laser product must also be kept by the local area.
- Any changes to equipment details, including location or disposal of Class 3R, 3B, 4 or Class 1 laser product with embedded Class 3B and/or Class 4 lasers, should be made to the Health and Safety team at HealthandSafety@newcastle.edu.au.

(ii) Training and risk assessments

- University provides a basic laser safety training through online Laboratory Safety Introduction module and additionally, the Laser safety training course on Discover
- Appropriate and adequate training ensured to workers by local laboratory manager. Keep the record of training
- Risk assessments and procedures, including normal operation procedure, emergency procedure, alignment procedure, maintenance and disposal are in place prior to work commencing and records kept of all workers who are trained in these procedures.
- Authorised personnel only access the laser operation area and to operate the laser, warning signs and labels on entry doors and equipment.

5.3. Personal Protective Equipment (PPE)

Laser radiation is potentially hazardous to human eyes and skin PPE to prevent should only be used in conjunction with high order controls and never as the only control used to prevent injury or harm. The type of PPE appropriate to the task will be assessed through the risk assessment process. Australian Standards, the manufacturing information and specific codes and standards released through government agencies must be consulted.

- PPE includes lab coats, appropriate laser safety glasses and gloves if required for a procedure and PPE appropriate to the chemical and/or physical hazard.

5.3.1 Laser Eye Protection (e.g. Laser goggles)

Eye protection is required when there is a potential for eye injury due to projectiles, chemicals, the laser beam itself and/or scattered or reflected radiation. For an individual who routinely needs to wear prescription glasses, the required eye protection shall accommodate the prescription glasses or be equipped with prescription lenses.

- The laser eye protection must be appropriate for the wavelength(s) and maximum intensity of the laser(s) being used and suitable for the work being done. The goggles selected shall include the optical density for laser wavelength and must be available and worn when operating laser and particularly when operating Class 3 or Class 4 lasers.

- Certain lasers and/or laser products containing multiple lasers may emit light at various wavelengths of both visible and invisible light. These systems should be thoroughly evaluated for the implementation of engineering controls and appropriate eyewear selection.
- For aligning purposes when using the beam at lower power, eye protection with less optical density than required for normal laser operation may be used, subject to risk assessment and procedure
- Ensure an appropriate storage and location for laser googles. Check eyewear for scratches and damages and other defects prior to each use.

5.3.2 Skin protection

- The potential for skin injury through exposure to laser light from Class 3B or Class 4 lasers must be controlled. Exposed skin should be covered using appropriate PPE (eg. lab coats, gloves, face shield)

6. Health Monitoring

Health monitoring is to protect a worker where there is a significant risk of exposure to a hazard to the worker's health or where there is a regulatory requirement.

6.1. A Health Monitoring and Immunisation Assessment (HSG 8.5: Health Monitoring and Immunisation) should be completed by the Leader or Supervisor of the work activity where a worker may be exposed to an identified exposure hazard.

6.2. A baseline eye examination is required for workers who work with open Class 3B and 4 lasers or modifiers of laser devices with incorporated high power lasers of Class 3B and/or Class 4 only.

6.3. If a worker or student is suspected to have had their eyes exposed to a Class 3B or 4 laser light, an eye examination will be required.
6.4. Please contact usafe@newcastle.edu.au to discuss health monitoring and to book in an eye examination.

7. Laser labelling and control area signage

7.1. Laser labelling should meet the requirements in AS/NZS IEC 60825.1:2014 ,refer to Appendix 2 for examples.
7.2. All laser equipment shall carry labels:
- Explanatory label (description of the hazard, which may include directions to avoid exposure).
- Warning label (hazard symbol).
- Aperture label (to identify where the radiation is being emitted).

7.3. Labels must be:
- Yellow background with black text, borders and symbols.
- Durable and permanently fixed to the equipment.
- Legible and clearly visible during operation of the equipment.
- Able to be seen without needing to be exposed to radiation.

7.4. Large lasers with a controllers and /or power supplies that are separate from the laser head should have:
- A warning label and explanatory label on the control panel.
- An aperture label on the laser head (close to where the radiation is emitted).

7.5. Lasers with control switches and aperture on the same device should have all labels placed on the device.
7.6. For very small laser components, where it is not feasible to attach any labels directly, appropriate labels must be attached to container where they are stored or the adjacent area when they are used.
7.7. The name and contact information of the Laboratory Manager and/or LSO should be included into the laboratory door signage and SOP.
7.8. A laser controlled area should be established where there is a reasonably foreseeable risk of harm arising from the use of lasers especially with Class 3 and 4 laser use, The area must be clearly identified and access to them limited to nominated personal with adequate training and personal under their control.
7.9. The door/s to each area where the laser is used must have the Rrisk area door sign with details of the hazards and personal protective equipment (PPE) required to enter the laser work area.

8. Training

Only individuals who have received appropriate training should be placed in control of laser(s) equipped systems. The training may be provider by the manufacturer or supplier of the system, laboratory manager, the LSO, the University Radiation Safety Officer or by an approved external organisation.

University provides training courses via Discover, these courses are provided for staff, honours and postgraduate students who wish to operate higher risk Class 3 or 4 laser equipment and/or

Class 1 with incorporated Class 3 and/or Class 4 laser(s), example confocal microscopes, mass spectrometer, particle sizer/counters.

9. Standards:

Users of lasers must, at a minimum, comply with the following Australian Standards:

• AS/NZS IEC 60825.1 Safety of laser products – Equipment classification and requirements

• AS/NZS IEC 60825.14 Safety of laser products – A user's guide

• AS/NZS IEC 60825.3 Safety of laser products - Guidance for laser displays and shows

• AS/NZS IEC 60825.4 Safety of laser products – Laser Guards

• AS/NZS 1337.4 Personal eye-protection - Filters and eye-protectors against laser radiation (laser eye-protectors)

• AS/NZS 1337.5 Personal eye-protection - Eye-protectors for adjustment work on lasers and laser systems (laser adjustment eye-protectors)

• AS/NZS 4173 Safe use of lasers and intense light sources in health care

Where areas do not comply with specific requirements as set out in the Australian Standards, alternative measures that provide equivalent or better protection must be adopted.

The implementation of control measures not specified by the Australian Standards must be risk assessed and controlled in line with these procedures.

10. Definitions

In the context of the Health and Safety Management System Framework:

Controlled Area	In which access is restricted for the purpose of protection from laser radiation.
Hazard	A situation, condition, or event, including a person's behaviour, that exposes a worker to a risk to their health or safety during the course of work in a workplace, that has the potential to cause injury, illness or even death or to damage buildings, plant or equipment
Risk	The likelihood that a hazard will cause harm and the consequence of that harm.
Laser	A laser is a device that emits light amplified through a process called stimulated emission. The word "laser" is an acronym for "light amplification by stimulated emission of radiation".
CW	Continuous Wave
AEL	Accessible Emission Limit

MPE	Maximum Permissible Exposure
Laser Safety Officer (LSO)	A person who is knowledgeable and competent in the assessment and control of laser hazards and has responsibility and authority for oversight of the control of laser hazards.
Radiation Safety Officer (RSO)	A qualified expert appointed by the responsible person to supervise radiation safety activities and to ensure radiation safety. An RSO is deemed to have the authority to implement procedures and to intervene in situations where safety has been or is being compromised.
SOP	Standard Operating Procedure: A set of step-by-step instructions compiled by an organization to help workers carry out routine operations
Leader / Supervisor	Any member of the University who is responsible for supervising staff and/or undergraduate or postgraduate students and/or for leading research projects.
Worker	Includes an employee, conjoint, student on work experience, contractor, sub-contractor, and volunteer. A person is a worker if the person carries out work in any capacity for the University or another person conducting a business or undertaking, including work as: (a) an employee, or (b) a contractor or subcontractor, or (c) an employee of a contractor or subcontractor, or (d) an employee of a labour hire company who has been assigned to work in the person's business or undertaking, or (e) an outworker, or (f) an apprentice or trainee, or (g) a student gaining work experience, or (h) a volunteer, or (i) a person of a prescribed class.

11. References & Related Documents

The following documentation is referenced in, or applicable to this Guideline:
HSG 1.2: Roles and Responsibilities
HSG 3.1: Health and Safety Risk Management
HSG 8.5: Health Monitoring and Immunisation.
HSG 8.2: Management Review of the HSMS

KRA 1.7: Laboratory Safety
KRA 1.12: Development of Standard Operating Procedures.

12. Amendment History

Version	Date of Issue	Approval	Section(s) Modified	Details of Amendment
1	February 2025	Health and Safety team	-	First version. Consultation with CRTC and LSO.

13. Appendices

Appendix 1

HAZARD RISK	POTENTIAL DANGER	CONTROLS
Laser radiation	Exposure to radiation from a laser whose emission are potentially hazardous – usually a laser of any class other that 1 or 2	Eliminate by enclosing the radiation at the source Use flame retardant screens to isolate users and bystanders from the radiation Interlock systems
Health Hazards	Direct exposure to the eyes or skin to laser radiation	Appropriate design of equipment; eliminate health hazards by enclosing the radiation at the source Personal protective equipment, e.g. wear appropriate laser safety glasses and skin protection gloves
Electricity	High voltage electricity Capacitors that store significant amounts of electric charge which can remain after the equipment has been disconnected from the electrical supply	Appropriate design of equipment; ensure all electrical terminals are enclosed and isolated from the laser user Develop safe work procedures for servicing work that might expose the electrical terminals, precautions must be taken to ensure the removal of stored energy
Collateral radiation	Other types of radiation other than laser radiation can be produced by the laser equipment	Ensure control measure protect the laser user from radiation if external laser casing needs to be removed Personal protective equipment

Hazardous chemicals	The material used as the active medium in several lasers can be toxic and carcinogenic	Adopt stringent storage, handling and disposal precautions Develop safe work procedures to document storage, handling and disposal requirements
Fume	Class 4 lasers can release hazardous particulate and gaseous by products through the interaction of the laser beam with the target material	Engineer equipment to allow for emergency stop aspects to be built into the design Develop safe work procedures that ensure that provisions are made to shut down the laser if hazardous particulate and gaseous by products are produced as the result of laser work
Noise	Discharge of capacitor banks within the laser power supply can generate potentially hazardous noise levels Ultrasonic emissions and repetitive noise from pulsed lasers	Engineering laser design to minimise the impact of noise Personal Protective Equipment including hearing protection
Mechanical hazards	Handling of ancillary items including gas cylinders, trailing cables and water circulation tubing can cause trip hazards	Engineer gas supply systems into building services Substitute large gas bottles for smaller gas bottles Tie up loose wires and pipes to eliminate trip hazards
Fire, explosion and thermal damage	Laser emission from high power laser can ignite target materials Laser emissions from lower class lasers can cause explosions in in combustible gases or in high concentrations of airborne dust, especially when concentrated over very small areas Internal components can explode, for example high pressure discharge lamps and capacitor banks Faulty equipment can cause flammable components to catch fire	Use of filters to reduce heat and radiation that are emitted from the laser Have firefighting equipment available Train laser user to use firefighting equipment Develop safe work procedures that require a laser user to always be present in the area that lasers are being used
Heat and cold	Internal parts of some laser can be hot Beam-steering mirrors used in conjunction with high-power	Engineer laser design to isolate the user from hot and cold hazards

	processing lasers can reach high temperatures Cryogenic cooling can sometimes be used with or in conjunction with laser equipment	
Temperature and humidity	Excessive high or low ambient temperatures can affect the performance of in-built laser safety features High levels of humidity can affect the performance of inbuilt laser safety features Condensation on optical components can affect beam transmission through the system	Use lasers in areas that have strict temperature control, for example airconditioned laboratories and other ventilation systems
Mechanical shock and vibration	Can cause misalignment of the optical path, generating hazardous errant beams	Engineer the laser set up so that the equipment is bolted down to a stable surface, for example a table
Atmospheric affects	A high-powered laser beam can ignite solvent vapour, dust and inflammable gases.	Do not use laser near flammable or combustible products including open solvent containers Use of non-flammable products such as nitrogen to clean system
Ergonomic considerations	Poor arrangement of the physical layout of the laser and associated equipment	Get a professional ergonomist to conduct an assessment Ensure that operators are not operating at a level where their eyes are at the same level as the laser beam

Appendix 2

Laser Warning signs and Labels

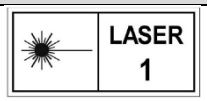
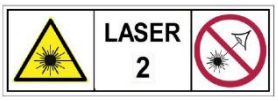
The following appendix 2 is a summary of the information on the laser labelling contained in Section 7 AS/NZS IEC 60825.1:2014.

Each laser product shall carry signs and label(s) in accordance with the requirements of the following clauses. The labels shall be durable permanently fixed, legible, and clearly visible during operation, maintenance or service, according to their purpose. They shall be so positioned that they can be read without the necessity for human exposure to laser radiation. Text borders and symbols shall be black on a yellow background except for Class 1, where this colour combination need not be used.

The wording of labels is recommended but not mandatory. Other wording that conveys the same meaning (including warning labels per earlier editions of IEC 60825-1) may be substituted. Annex C provides additional information about the laser classes, assumptions and limitations.

Each Class 3R, Class 3B and Class 4 laser product shall have affixed a label close to each aperture through which laser radiation in excess of the AEL for Class 1 or Class 2 is emitted.

Appendix 2. An explanatory labels.

Class	Affixed an explanatory label bearing the words:	Or Alternative label
Class 1	CLASS 1 LASER PRODUCT	
Class 1M	LASER RADIATION DO NOT EXPOSE USERS OF TELESCOPIC OPTICS CLASS 1M LASER PRODUCT	
Class 1C	LASER RADIATION FOLLOW INSTRUCTIONS CLASS 1C LASER PRODUCT	
Class 2	LASER RADIATION DO NOT STARE INTO BEAM CLASS 2 LASER PRODUCT	
Class 2M	LASER RADIATION DO NOT STARE INTO BEAM OR EXPOSE USERS OF TELESCOPIC OPTICS CLASS 2M LASER PRODUCT	
Class 3R	LASER RADIATION AVOID DIRECT EYE EXPOSURE CLASS 3R LASER PRODUCT	
Class 3B	WARNING – LASER RADIATION AVOID EXPOSURE TO BEAM CLASS 3B LASER PRODUCT	
Class 4	DANGER − LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT	

Aperture Label

	Affixed an explanatory label bearing the words:	Alternative label
Aperture Label	LASER APERTURE or APERTURE FOR LASER RADIATION or AVOID EXPOSURE – LASER RADIATION IS EMITTED FROM THIS APERTURE