UNIVERSITY
OF WOLLONGONG
AUSTRALIA

UOW SAFE@WORK

LASER SAFETY GUIDELINES

Contents

1 Introduction

The University of Wollongong is committed to managing health and safety risks, including those associated with the use of lasers, through the effective implementation of the WHS Management System (WHSMS). Laser users are required to ensure that the requirements of the AS/NZS IEC 60825 series are implemented into the use of lasers.

2 Scope

Lasers differ from other sources of non-ionising radiation in both the mechanism of operation and the quality of radiation produced. Laser beams usually are of a small diameter with low divergence and a high power density. Lasers can either emit radiation continuously or in a single pulse or a series of pulses. The output is either monochromatic or consists of a number of specific wavelengths.

The objective of this guideline is to:

- protect persons from laser radiation in the wavelength range 100 nm to 1 mm by indicating low risk working levels of laser radiation;
- provide information to the user ensuring procedures providing adequate controls are developed;
- ensure there is adequate warning of hazards associated with accessible radiation from laser products through signs, labels and instruction; and
- reduce the possibility of injury by minimising unnecessary accessible radiation, provide improved control of laser radiation hazards through protective features, and to provide safe usage of laser products by identifying user control measures.

3 Definitions

The following definitions apply to this document:

Infrared (IR) radiation	Electromagnetic energy having a wavelength of 700nm to 1mm (Near IR – 700 nm to 1400 nm; Far IR – 1400 nm to 1 mm).
Laser	Acronym for "Light Amplification by Stimulated Emission of Radiation" and defined as any device which can be made to produce or amplify electromagnetic radiation in the wavelength range from 100 nm to 1mm primarily by the process of controlled stimulated emission (AS/IEC 60825.1). Lasers emit in the Ultraviolet, Infrared & Visible parts of the electromagnetic spectrum.
Laser eye screening	This is a specific eye test which includes photographing the retina as a baseline in case of future damage.
Laser pointer	A type of portable pen-shaped laser normally designed to be held by hand and are most commonly used to project a point of light that can highlight items of interest, for example during a presentation. Most laser pointers have a low output beam power (less than 1 mW). In NSW, laser pointers that have outputs of ≥1mW are illegal without a firearms licence.
Maximum Permissible Exposure (*MPE*)	The level of laser radiation to which, under normal circumstances, persons may be exposed without suffering adverse effects.
Non-ionising radiation	Electromagnetic radiation not capable of producing ion pairs in biological material(s).
Ultraviolet (UV) radiation	Electromagnetic energy having a wavelength of 100nm to 400nm (UV-A 315-400 nm; UV-B 280-315 nm; UV-C 180-280 nm).
Visible light radiation	Electromagnetic energy having a wavelength of 400nm to 700nm.

4 Responsibilities

4.1 Deans, Directors and Heads of Units

Deans, Directors and Heads of Units are responsible for ensuring processes and resources are in place to ensure that any work requiring the use of laser can be completed safely and in accordance with this guideline.

4.2 Supervisors

Supervisors are responsible for ensuring that laser operators work in accordance with this guideline. Supervisors can do this by ensuring that, as a minimum, risk management activities are undertaken, and that personnel who are operating lasers are provided with suitable levels of training, supervision and instruction.

4.3 Laser Operators

Laser operators are responsible for completing a risk assessment for the work being undertaken that involves the use of lasers. They are also expected to work in accordance with any safe operating procedures or safe work procedures as well as ensuring necessary instructions, from the relevant laser equipment's operational manual, are implemented into safe work procedures.

5 Laser Classification and Modification

5.1 Classification

The AS/NZS IEC 60825 series divide lasers into eight classes according to accessible emission limits which are given in tables for a range of laser wavelengths and exposure times. The classes are: 1,1C, 1M, 2, 3A, 3B, 3R (restricted) and 4.

Lasers are classed according to the hazard level with class 4 lasers being the highest. The power of the laser can be either in a continuous or pulsed mode, with a specified wavelength/colour. Class 4 lasers can cause significant damage to the human body and there are strict requirements for their use.

The classification system can be broadly described in the following terms:

- **Class 1** includes any laser product which during operation does not permit human access to accessible laser radiation in excess of the accessible emission limits of Class 1 for applicable wavelengths and emission durations.
- **Class 1C** any laser product which is designed explicitly for contact applications to the skin or non-ocular tissue and that:
    - during operation ocular hazard is prevented by engineering means, i.e. the accessible emission is stopped or reduced to below the accessible emission limits 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; and
    - the laser product complies with the applicable vertical standards.
- **Class 1M** any laser product in the wavelength range from 302.5 nm to 4 000 nm which during operation does not permit human access to accessible laser radiation in excess of the accessible emission limits of Class 1 for applicable wavelengths and emission durations.
- Class 1 and 1M lasers are those which are incapable of damaging the eyes or skin because of either engineered design or inherently low power output. The lasers used in CD players are the most common example of this category.

- **Class 2** include any laser product in the wavelength range from 400 nm to 700 nm which during operation does not permit human access to accessible laser radiation in excess of the accessible emission limits of Class 2 for applicable wavelengths and emission durations.
  Class 2 lasers have sufficient power output to cause damage to the eyes if viewed continuously. However, their outputs are low enough to allow the natural aversion responses, such as blinking, to prevent damage. Additional hazard control measures take the form of cautionary signs or labels. The laser pointers often used by conference presenters are common examples.
- **Class 2M** include any laser product in the wavelength range from 400 nm to 700 nm which during operation does not permit human access to accessible laser radiation in excess of the accessible emission limits of Class 2 for applicable wavelengths and emission durations.
  Class 2M lasers can be hazardous if the beam is viewed directly with optical instruments.
- **Class 3A** lasers are mostly dangerous in combination with optical instruments which change the beam diameter or power density, though even without optical instrument enhancement direct contact with the eye for over two minutes may cause serious damage to the retina.
- **Class 3R (Restricted) and 3B** include any laser products which during operation permits human access to laser radiation in excess of the accessible emission limits of Class 1 and Class 2, as applicable, but which does not permit human access to laser radiation in excess of the accessible emission limits of Classes 3R and 3B.
  Class 3R lasers have the potential to cause damage to the eyes from intra-beam viewing and precautions are required to prevent either direct viewing or viewing with optical instruments.
  Class 3B lasers are more hazardous because of either higher output or operation outside visible wavelengths. These are powerful enough to cause eye damage in a time shorter than the aversion response, human blink reflex or the blink reflex is by-passed due to the invisibility of the beam. In addition, specular reflections may also be hazardous. In general, more stringent controls are needed to prevent exposure.
- **Class 4** lasers include any laser product which permits human access to laser radiation in excess of the accessible emission limits of Class 3B. They are high power devices capable of producing eye damage even from diffuse reflection. Skin damage is also possible from even brief exposures. Class 4 lasers may also constitute a fire hazard. Examples of class 4 lasers include entertainment lasers, surgical lasers and those used in the plastic, wood and metal fabrication industries.

5.2 Modification

Modifications to the design of a laser can change the intended function of that laser. Modification to laser design can place the laser into a higher or lower classification within the scope of AS/NZS IEC 60825.1. If this is the case then the person completing the modification must ensure that the laser is reclassified and relabeled within the scope of AS/NZS IEC 60825.1.

6 Engineering and Labelling Specifications

Product manufactures are required to build in certain safety features into lasers depending on the class. All required engineering specifications have been detailed in AS/NZS IEC 60825.1.

Additionally, each laser product is required to be labeled in accordance with AS/NZS IEC 60825.1. Labels shall be durable, permanently affixed, legible and clearly visible during operation, maintenance and service, according to their purpose. Labels shall be so positioned that they can be read without the necessity for human exposure to laser radiation in excess of the accessible emission limits for Class 1. Text borders and symbols shall be black on a yellow background except for Class 1, where this color combination need not be used, e.g.:

7 Informational Requirements

It is the responsibility of the manufacturer to provide user instruction or an operation manual that contains all relevant safety information. AS/NZS IEC 60825.1 outlines the safety information that the manufacturer needs to provide.

8 Risk Management

8.1 Identifying Hazards

Any work that involves the installation, operation, maintenance, service or disposal of laser equipment can be exposed to a number of hazards. Laser radiation is a major hazard associated with laser use. Additional hazards such as electricity, fumes, and high-pressure gases can also potentially cause harm to those working with lasers.

Lasers are capable of producing intense beams of coherent radiation at optical, UV and IR wavelengths. While lasers vary greatly in power output, wavelength and purpose, the hazard potential of the types used for research purposes can be significant. Because of the very high spectral brightness of most laser sources, such radiation can be extremely hazardous to the eyes and the skin and a number of cases of serious injury, including loss of sight, have been documented.

AS/NZS IEC 60825.14 outlines a number of hazards associated with laser use. The following table summarises the hazards listed in the standard and outlines possible control solutions:

Hazard	Potential Danger	Risk 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
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
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 ▪ Interlock systems
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 a number of 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

Hazard	Potential Danger	Risk Controls
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 hazard	▪ 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 processing lasers can reach high temperatures ▪ Cryogenic cooling can sometimes be used with or in conjunction with laser equipment	▪ Engineer laser design to isolate the user from hot and cold hazards
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 in-built 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 air conditioned 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 systems
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

Table 1 Hazards associated with laser usage and possible control measures

The use of all classifications of lasers can give rise to a number of hazards arising from the direct exposure of the eyes or skin to laser radiation. Whenever it is reasonably practicable health hazards should be controlled through effective engineering design. When it is not reasonably practicable to do so the user will need to manage the risk associated with health hazards through other control options.

Eyes are the most susceptible to damage from lasers. Different parts of the eyes are susceptible to different wavelengths. Damage can occur from heating, photochemical reactions and explosive rupture. Appropriate controls are essential to prevent ocular damage.

Skin is less at risk from damage caused by lasers, but exposure to lasers still need to be managed appropriately to minimise the potential for skin burns.

8.2 Risk Assessment and Control

The assessment of risk associated with any identified hazards should be done in accordance with the UOW Risk Management Guidelines.

8.3 Control

The completion of a risk assessment will help to determine any further controls to be adopted in conjunction with this guideline.

Any risk associated with lasers hazards can largely be managed by through the provision of engineering controls. When engineering controls cannot manage all risk associated with laser hazard the use of administrative controls and personal protective equipment can be used either singly or in conjunction with laser controls.

Low powered lasers, such as those incorporated in consumer products, usually have a high degree of inherent safety control measures engineered into the design and no additional safety measures are needed. The lasers used in research are often high power units and while engineered safety features are required a risk assessment is required to be completed in order to identify additional hazards that have not been managed by engineering controls. Written safe working procedures are also important – particularly in research applications where equipment configurations may need to be altered frequently. This increases the importance of the safety awareness of users because more reliance must be placed on procedural safety measures and the use of protective equipment such as safety goggles.

As a minimum the following controls must be implemented when working with lasers:

8.3.1 Safe Work Procedures

Written safe working procedures are also important – particularly in research applications where equipment configurations may need to be altered frequently. Further information on Safe Work Procedures can be found at the link provided.

8.3.2 Training

All users should be made aware of any hazards (including associated hazards) to which they may be exposed during the use of laser equipment, and of the procedures necessary to ensure protection. Adequate warnings including the laser hazard symbol should be displayed.

Sufficient local instruction or training should be given in order that users have the necessary understanding to avoid placing themselves and others at unacceptable risk.

Such instruction and training should be commensurate with the type of hazard and appropriate for the employees concerned. It should include, but need not be limited to the:

- University's procedures for safe laser use including local procedures and rules
- risks of harm that could arise from the use and reasonably foreseeable misuse of the laser equipment
- meaning of displayed warning signs
- correct use and operation of the laser equipment, and of associated equipment, including personal protective equipment (where applicable)
- procedures to be followed in the event of an actual or suspected accident or other safety-related incident.

University approved Laser Safety training is required for all users of Class 3B and Class 4 Lasers. Laser Safety training should be completed prior to operating or working with laser products, and repeated as frequently as necessary in order to ensure continuing compliance with safety procedures.

Records of training are to be kept.

8.3.3 Administrative Controls

An administrative framework is needed to ensure that the procedures and conditions necessary for a safe working environment are put in place. Where lasers of class 3 (all 3 subdivisions) and class 4 are used, more detailed (and in some cases, site-specific) safe working rules and emergency procedure manuals will need to be developed. Advice can be obtained from the University Laser Safety Advisor (LSA) regarding the content of such safety manuals.

To aid in managing the risk associated with the use of lasers, the following controls are to be implemented where lasers are used:

1. Each School or Unit which uses lasers of classes 3 or 4 shall keep a register of the equipment (Laser Equipment Registration Form) in their possession. The register is to include full details of make, model, serial number, power output, classification and the designated purpose for use of each particular laser. Where a laser is employed as a research tool capable of multiple uses, this should be indicated.
2. The head of a department or research centre where lasers are used shall appoint a person with appropriate knowledge to act as Local Laser Safety Supervisor (LSS). Such deputies shall also be appointed as are necessary to ensure availability of expertise, taking into account leave and other absences.
3. Every laser of Class 3 or 4 shall have affixed to it (in addition to such labels required under appropriate Australian standards) the name of the Local LSS and a telephone number at which they may be contacted.
4. Appropriate safe operating procedures must be available in a department or research centre in which lasers of classes 3 or 4 are used. The procedures manual must list the hazards associated with the particular lasers used in the department or centre, the conditions under which they can be used and the precautions necessary to ensure safety.
5. Lasers for use in surveying, building or construction must be used in compliance with AS 2397. As with AS/NZS IEC 60825.1, a copy is to be kept by the University LSA, Local LSS and made available to users.
6. Pre-placement or periodic examination of the eye is generally not considered essential or cost effective but an examination of the eye by an optometrist or ophthalmologist should be conducted after an accidental exposure in excess of the MPE and should follow the details given in AS/NZS IEC 60825.14.
7. Pre-placement or periodic examination of the skin is generally not considered essential or cost effective but an examination of the skin by a medical practitioner should be conducted after an accidental exposure in excess of the MPE in conjunction with a full biophysical investigation of the accident.

8.3.4 Specific Controls for Class 4 Lasers

Class 4 lasers are required to have:

- specific safety protocols including remote interlock
- beam stop or attenuator
- warning signs and labelling
- elimination of specular reflections
- use of eye protection where there is a potential eye hazard
- use of protective clothing
- requirement for medical examination immediately if there is a suspected injury
- provision of appropriate training on safe use of equipment including maintenance
- safe work procedures for control of hazards

Considerations for workshop and laboratory design for class 4 lasers include:

- no windows
- an area for storing protective eyewear
- key locks to prevent unauthorised and unprotected personnel from entering
- a non-defeatable door interlock
- signs at entrance to lab
- laser beam path must be enclosed
- beams must be positively terminated
- laser work area must be free of unnecessary specular surfaces
- curtain materials must be fire resistant
- a clearly visible power cut-off switch which kills power to the laser
- a warning light must be located outside of the lab door to indicate when the laser if firing
- other controls as necessary

Check with the supplier to ensure the equipment containing the lasers complies with Australian standards, In particular there is a new checklist under AS/NZS IEC 60825.5 which is a checklist for manufacturers of laser products.

9 Related Documentation

- AS 2397 Safe Use of Lasers in the Building and Construction Industry
- AS/NZS 4173 Guide to the Safe Use of Lasers in Health Care
- AS/NZS IEC 60825 Safety of Laser Products (series)
  - Part 1 – Equipment classification and requirements
  - Part 3 – Guidance for laser displays and shows
  - Part 4 – Laser guards
  - Part 5 – Manufacturers checklist for IEC 60825-1
  - Part 13 – Measurements for classification of laser products
  - Part 14 – A user's guide
- ICNIRP Guidelines on Limits of Exposure to Laser Radiation of Wavelengths between 180 nm and 1,000 µm (International Commission on Non-Ionising Radiation Protection)
- Laser Classifications and Potential Hazards Information Sheet (Safe Work Australia)
- OHS Series 68 The Use of Lasers in the Workplace (International Labour Office, Geneva)
- RPS 18 Safety Guide for the Use of Radiation in Schools (ARPANSA)

10 Version Details

Version Control	Date Released	Approved By	Amendment
1	November 1999	WHS Manager	New document created
2	May 2003	WHS Manager	Documented updated to reflect current requirements
3	April 2006	WHS Manager	Documented updated to reflect current requirements
4	January 2010	WHS Manager	Document updated to include additional details
5	August 2010	WHS Manager	Document updated to incorporate the Personnel name change to Human Resources Division.
6	March 2012	WHS Manager	Re-brand
7	January 2013	WHS Manager	Scheduled Update – Incorporation of AS/NZS IEC 60825 series.
8	April 2015	WHS Manager	Amendments made to introduction and responsibilities sections.
9	July 2018	WHS Manager	Scheduled review to capture AS/NZS IEC 60825 changes and to include additional details which reflect current requirements including eye examination for Class 3B and Class 4 Lasers.
10	June 2020	WHS Manager	Removed requirement for commencement and termination eye examination as it has been removed from the Australian Standard.