Laser Safety Standard

Last Update: 9 March 2011
Owner: Manager OHS

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1 Nature of the Hazard

Lasers are capable of producing intense beams of coherent radiation at optical, ultra violet and infra-red wavelengths. While lasers vary greatly in power output, wavelength and purpose, the hazard potential of the types used for research purposes can be significant. Laser 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. Please see the Australian Standard for further details on nature of laser hazards.

As a result, a number of international and Australian standards which set out requirements for laser safety have been published or revised in recent years.

This University standard provides directions on the hazard control and administrative measures needed to safely use lasers in the University.

2 Recommended Compliance Procedure

Note: The head of a faculty, school, division or research centre where lasers are used is responsible for ensuring that an effective compliance program is in place.

Methodology	Resources / Tools
Step 1: Required References Obtain a copy of the *Australian Standard AS/NZS 2211.1: 2004. 'Safety of Laser Products. Part 1: Equipment Classification, Requirements and User's Guide'.* Any specific requirements of this Australian Standard should be complied with. Lasers for use in surveying, building or construction must be used in compliance with Australian Standard AS 2397-1993: *Safe Use of Lasers in the Building and Construction Industry.* In areas where Class 3 or Class 4 lasers are used, a copy is to be kept by the Laser Safety Officer or supervisor, and made available to users.	You can obtain on-line access to Australian Standards from the University Library. Click on 'Articles via databases' on the OHS Library Resources homepage and then select 'Australian Standards Online Premium'. Access is through the link http://deakin.libguides.com/occhealthsafety
Step 2: Survey Identification of All Lasers Conduct a survey of all lasers in your area. Complete and maintain a register of all the laser equipment identified in your area (school, division or research centre)	Use the information to complete the Laser Equipment Registration Form
Step 3: Maintain a Laser Equipment Register A completed copy of the Laser Equipment Registration Form must be forwarded to the University Radiation Safety Officer (RSO) for central records and a copy kept with the school, division or research centre as a site record.	Note: For Class 3 (i.e. Class 3R and 3B) or Class 4 lasers, the register is to include full details of make, model, serial number, laser class, laser power output and frequency, the designated purpose for use of each particular laser and the laser equipment's location/staff contact information.
Step 4: Appointment of Laser Safety Officer The head of a school, division or research centre where Class 3 or 4 lasers are used shall appoint a person who is knowledgeable in the evaluation and control of laser hazards to act as a Laser Safety Officer (LSO). Such deputies shall also be appointed as are necessary to ensure availability of expertise, taking into account leave and other absences.	Please refer to section on Laser Safety Officer for more information.
Step 5: Complete '*Laser Hazard Identification Checklist* ' Under the guidance of the Laser Safety Officer, laser equipment supervisors/custodians are to complete the Laser Hazard Identification Checklist for all Class 3 and Class 4 laser equipment used in your area.	
Step 6: Forward copy to Radiation Safety Officer A completed copy of this checklist must be forwarded to the Deakin University Radiation Safety Officer and a copy kept with the school, division or research centre as a site record.	

Methodology	Resources / Tools
Step 7: Risk Assessment of Identified Hazards Laser equipment supervisors/custodians are to conduct a risk assessment of each hazard identified for the laser equipment and develop and implement appropriate control measures as necessary. Risk assessments must be reviewed: • when modifications are made to the laser equipment, • when processes change • or at least every five years.	Please see Risk Assessments and Control Measures for additional details on appropriate control measures to adopt. The hazard identification, risk assessment and control process must be undertaken in consultation with the department's Laser Safety Officer and/or the University Radiation Safety Officer as well as OHS representatives and users
Step 8: Complete '*Laser User Registration Form'* All persons who use Class 3 or Class 4 lasers are to complete the Laser User Registration Form. A completed copy of this form must be forwarded to both the Deakin University Radiation Safety Officer and a copy kept with the school, division or research centre for local records.	The information provided will assist the University to continue surveillance of users, procedures and to arrange medical examinations if required.
Step 9: Complete *'Authority to Use a Class 3 or Class 4 Laser Form'* All persons who use Class 3 or Class 4 lasers should also complete the Authority to Use a Class 3 or Class 4 Laser Form. *A* copy of this form should be kept with the school, division or research centre and records maintained.	In order to assist the site Laser Safety Officer /supervisors control access to high hazard level laser equipment and ensure only appropriately trained and approved personnel can use the specific laser equipment.
Step 10: Develop Safe Working Procedures Appropriate Safe Working Procedures (SWPs) and emergency procedures must be available in each school, division or research centre where Class 3 (i.e. Class 3R and 3B) or Class 4 lasers are used. The SWPs must list the hazards associated with the particular lasers used in the area, the conditions under which they can be used and the precautions/control measures necessary to ensure safety.	Please see Guidelines for Laser Safety 'Safe Working Procedures' and Checklist of Laser Hazard Control Procedures for further details. Safe Working Instructions Guideline provides general advice on developing procedures. Advice can be obtained from the Deakin University Radiation Safety Officer regarding the content of these procedures.
Step 11: Put up Laser Warning Signs Rooms where Class 3B or Class 4 lasers are used shall have a warning sign at the entrance giving the name of the faculty's, school's or centre's Laser Safety Officer and a telephone number at which they may be contacted.	Please refer Laser Area Warning Signs for details on the appropriate warning signs to put up.

Methodology	Resources / Tools
Step 12: Training and Induction As the operation of laser systems can represent a hazard not only to the user but also to other people over a considerable distance, only persons who have received training to an appropriate level should be placed in control of such systems. All users of laser equipment are also required to complete the online '*Working with Lasers at Deakin University'* laser safety information training, prior to their operation of the laser equipment. All staff and students should also read Safe Use of Laser Pointers – Information Sheet. Refresher training is required every 2 years. Training records must be kept for at least 5 years.	Please refer Training and Induction for additional information. Access to this laser safety information training is available online at Working with Lasers at Deakin University Please refer to Risk Assessments and Control Measures and Guidelines for Laser Safety 'Safe Working Procedures'
Step 13: Medical Surveillance In view of the potential risks that may affect laser workers, the University recommends that Faculties/Divisions provide the following medical examinations for laser workers working in their areas/departments: a) Appropriate laser eye examinations before commencement of work with Class 3B and Class 4 lasers and at the termination of employment or laser operations. b) Following any apparent or suspected laser radiation exposure. In this case, the eye examination should also be supplemented by skin examinations. c) Following any serious injury to, or illness of the eye.	Please refer Medical Surveillance and Procedure for Organising Laser Eye Examinations for more details.
Step 14: Review of Risk Control Measures Carry out regular reviews of risk control measures at least every 5 years: • To monitor implementation • To ensure their effectiveness, • When there are changes in conditions or procedures and modification of equipment.	

Notes

- The hazard identification, risk assessment and control process should be undertaken in consultation with users of the lasers and the relevant Health and Safety Representative (HSR).
- Each step in the process must be documented.

3 Laser References – Legislation and Australian Standards

Those responsible for laser use need to be aware that while laser controls are not addressed specifically in current legislation, injuries caused by a laser fall within the domain of the employer's obligations set out in the Occupational Health and Safety Act of Victoria and possibly common law liability. In addition, failure to implement appropriate safety standards would constitute a breach the OHS Act. This reinforces the importance of compliance with well-recognised Australian Standards based on international recommendations.

There are several important Australian Standards applicable to lasers:

- *AS/NZS 2211.1:2004 'Safety of Laser Products. Part 1: Equipment Classification, Requirements and User's Guide' AS/NZS 2211.10:2004 'Safety of Laser Products. Part 10: Application Guidelines and Explanatory Notes to AS/NZ 2211.1',*
- *AS/NZS ISO 11553:2004 'Safety of Machinery – Laser Processing Machines – Safety Requirements'*
- *AS/NZS 2397:1993 'Safe Use of Lasers in the Building and Construction Industry'.*

You can obtain on-line access to Australian Standards from the University Library. Click on 'Articles via databases' on the OHS Library Resources homepage and then select 'Australian Standards Online Premium'. Access is through the link http://deakin.libguides.com/occhealthsafety.

4 Risk Assessments and Control Measures

Three aspects of the use of lasers need to be taken into account in the evaluation of the possible hazards and in the application of control measures:

- The capability of the laser or laser system to injure personnel. This includes any consideration of human access to the main exit port or any subsidiary port

- The environment in which the laser is used, specifically:
  - Laboratory and workshop environments where engineering controls may play the greatest role;
  - Outdoor and construction environments where administrative controls often provide the only reasonable approach to safe operation;
  - Display and demonstration environments, where pre-planning, delineation and control of access often provide the only reasonably practicable approach to safe operation.

- The level of training of the personnel who operate the laser or who may be exposed to its radiation.

The practical means for the risk assessment of laser radiation hazards is to base the assessment and control measures on the classification system. The classification scheme relates specifically to the accessible emission from the laser system and the potential hazard based on its physical characteristics. However, environmental and personnel factors are also relevant in determining the control measures required, and a responsible person should be designated as Laser Safety Officer, to be responsible for providing informed judgments on situations not specifically covered in this guide or the Australian Standards.

Laser hazards may be controlled by the use of engineered controls, administrative controls and personal protective equipment, either singly or in combination. As a general principle, engineered controls are preferred where appreciable hazards exist, although these may need in some cases to be supplemented by further administrative controls. Low powered lasers, such as those incorporated in consumer products, usually have a high degree of inherent safety and no additional safety measures are needed.

The lasers used in research are often high power units and while engineered safety features are required, 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 personal protective equipment, such as appropriate safety goggles.

4.1 Administrative Control Requirements

An administrative framework is needed to ensure that the procedures and conditions necessary for a safe working environment are put in place.

Laser equipment supervisors/custodians responsible for all Class 3 and Class 4 laser equipment used in their area are required to complete the Laser Hazard Identification Checklist. A completed copy of this checklist must be forwarded to the Deakin University Radiation Safety Officer and a copy kept with the school, division or research centre as a site record.

In addition, where lasers of Class 3 (all Class 3 subdivisions) and Class 4 are used, more detailed (and in some cases, site-specific) Safe Working Procedures (SWPs) and emergency procedure manuals will need to be developed. Advice can be obtained from the Deakin University Radiation Safety Officer regarding the content of such safety manuals.

Please see Guidelines for Laser Safety 'Safe Working Procedures' for details on development of safe working procedures when using lasers.

4.2 Personal Protection

The need to use personal protection against the hazardous effects of laser operation should be kept to a minimum using engineering design, beam enclosures and administrative controls. Nevertheless, when personnel may be exposed to potentially hazardous laser radiation (Class 3B and Class 4) adequate personal protection should be provided.

4.3 Eye Protection for Laser Use

In general, whilst in laboratories, eye wear must be worn at all times. With lasers in the workplace, it is of greater importance to use eye protection specific to the hazards that may occur or be present. With lasers, the power, class and type (viz., wavelength) is of great importance to the selection of the right eye protection.

With the higher classes of laser, there is no second chance - one exposure may be enough to produce blindness.

4.3.1 General

Information on eye protectors suitable for use with particular lasers and operations is given in BS EN 207, BS EN 208, AS/NZS 2211.1:2004 and AS/NZS 1336-1997. *No single type of eyewear will provide protection against all wavelengths or levels of power of laser radiation.* The following should be considered, when specifying suitable protective eyewear:

- Wavelength(s) of operation.
- Radiant exposure or irradiance.
- Maximum permissible exposure (MPE).
- Optical density of eyewear at laser output wavelength.
- Visible light transmission requirements.
- Radiant exposure or irradiance at which damage to eyewear occurs.
- Need for prescription glasses.
- Comfort and ventilation.
- Degradation or modification of absorbing media, even if temporary or transient.
- Strength of materials (resistance to shock).
- Peripheral vision requirements.
- Any relevant legislation.

Eye protection which is designed to provide adequate protection against specific laser wavelengths should be used in all hazard areas where Class 2M, Class 3R laser products emitting energy outside of the 400 nm to 700 nm wavelength range, Class 3B or Class 4 lasers are in use.

The exceptions to this are as follows:

- When engineering and administrative controls are such as to eliminate potential exposure in excess of the applicable MPE.
- When, due to the unusual operating requirements, the use of eye protection is not practicable. Such operating procedures should only be undertaken with the approval of the Laser Safety Officer.

4.3.2 Identification of eyewear

All laser protective eyewear shall be clearly labelled with information adequate to ensure the proper choice of eyewear with particular lasers.

4.3.3 Required optical density

The spectral optical density D_λ of laser protective eyewear is normally highly wavelength dependent. Where protective eyewear is required to cover a band of radiation, the minimum value of D_λ measured within the band shall be quoted. The value of D_λ required to give eye protection can be calculated from the equation:

$D\lambda = \log 10\ Ho / MPE$ where *Ho* is the expected unprotected eye exposure level.

4.3.4 Protective eyewear

Protective eyewear should be comfortable to wear, provide as wide a field of view as possible, maintain a close fit while still providing adequate ventilation to avoid problems in misting up and provide adequate visual transmittance. Care should be taken to avoid, as far as is possible, the use of flat reflecting surfaces which might cause hazardous specular reflections. It is important that the frame and any sidepieces should give equivalent protection to that afforded by the lens(es). Special attention must be given to the resistance and stability against laser radiation when choosing eyewear for use with Class 4 laser products.

4.4 Skin Protection

If it is necessary to work in close proximity to an exposed high intensity laser, suitable gloves and cover for the forearms should be used. This is most important if the laser is running in the ultra-violet. Very large peak powers with pulsed ultra-violet laser may be particularly dangerous. At the minimum, a natural fibre long sleeved laboratory coat must be worn.

Where personnel may be exposed to levels of radiation that exceed the MPE for the skin, suitable clothing should be provided. Class 4 lasers present a potential fire hazard and protective clothing worn should be made from a suitable flame and heat resistant material. Special attention must also be given to the resistance and stability against laser radiation when choosing clothing for use with Class 4 lasers.

4.5 Respiratory Protection

This is not generally required unless there is a chance of fumes being created or the work involves exposure of laser to chemicals. Engineering controls are the first choice for respiratory protection but if this is inadequate or not used then the appropriate respiratory protection shall be used.

Where there is the risk of fumes being produced or the cryogenic or laser gases may be present in the working atmosphere, then reference to the University's Hazardous Substances Guidelines and Procedures, the Victoria Hazardous Substances Regulation, and the Commonwealth Code of Practice and guidelines should be consulted and incorporated into the procedures for the work.

4.6 Storage of Personal Protective Equipment

PPE can be stored outside the Laser Control Area (where practical) to allow user entry while wearing the appropriate PPE.

4.7 Laser Area Warning Signs (As per Australian Standard AS 2211.1:2004 and AS 2211.1:1997)

All entrances to areas shall be posted with the following warning signs, of an appropriate size to be easily seen and read.

The Australian Standard recommends signs of type Figure 1 have a base width of 150, 200, 400 or 600mm. Generally the university recommends a Figure 1 type sign have a base width of 200 mm.

Figure 1. Laser Warning Sign

The Australian Standard recommends that signs of the type shown in Figure 2, should have a base width of 250 or 400mm. However, the width can be of any size to accommodate the appropriate wording required.

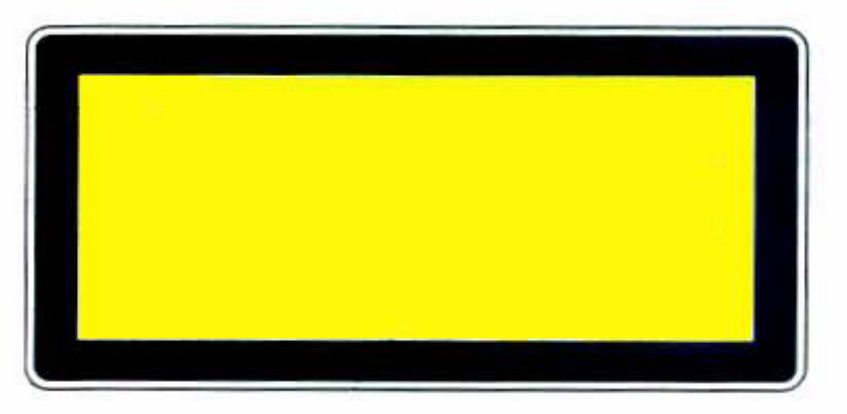

Figure 2. Worded Laser Warning giving specific instructions.
See following text for exact wording to be incorporated in sign.

Each Class 1 laser area shall have affixed an explanatory sign bearing the words:

CLASS 1 LASER PRODUCT

Each Class 1M laser area shall have affixed an explanatory sign bearing the words:

LASER RADIATION
DO NOT VIEW DIRECTLY WITH OPTICAL INSTRUMENTS
CLASS 1M LASER PRODUCT

Each Class 2 laser area shall have affixed an explanatory sign bearing the words listed below:

LASER RADIATION
DO NOT STARE INTO BEAM
CLASS 2 LASER PRODUCT

Each Class 2M laser area shall have affixed an explanatory sign bearing the words:

LASER RADIATION
DO NOT STARE INTO THE BEAM OR VIEW
DIRECTLY WITH OPTICAL INSTRUMENTS
CLASS 2M LASER PRODUCT

Each Class 3R (in the wavelength range 400 nm to 1,400 nm) laser area shall have affixed an explanatory label bearing the words listed below:

LASER RADIATION
AVOID DIRECT EYE EXPOSURE

CLASS 3R LASER PRODUCT

For other wavelengths, each Class 3R laser area shall have affixed an explanatory label bearing the words:

LASER RADIATION
AVOID EXPOSURE TO BEAM
CLASS 3R LASER PRODUCT

Each Class 3B laser area shall have affixed an explanatory label bearing the words listed below:

LASER RADIATION
AVOID EXPOSURE TO BEAM
CLASS 3B LASER PRODUCT

Each Class 4 laser area shall have affixed an explanatory label bearing the words listed below:

LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT

In addition, Class 3 & 4 laser areas shall display a sign as shown below:

4.8 Checklist of Laser Hazard Control Procedures

The following checklist can be used as a training guide to assist laser users in hazard identification, risk assessment and control of laser hazards. This is to ensure the safe operation of laser equipment in:

- Laboratory and workshop environments
- Outdoor and construction environments
- Display and demonstration environments
- Classroom and lecture environments, specifically for the correct selection, purchase and use of laser pointers.

Thus, all users of laser equipment in Deakin University must complete this checklist as a training tool prior to their operation of the laser(s). Please go to Checklist of Laser Hazard Control Procedures to obtain and complete this checklist.

5 Guidelines for Laser Safety 'Safe Working Procedures'

The following guidelines will assist you to develop a departmental or local area set of laser equipment 'Safe Working Procedures (SWP)'. Not all of the following points will be applicable, but all should be considered in the development of the procedures.

5.1 Basic Guidance

The following must be considered in the development of a SWP:

- The written SWP must discuss beam alignment and normal operation (check manufacturer's recommendations) for each laser system. It is advisable to include non-beam hazard management and servicing in the SWP.
- To ensure the SWP is read and used, the document should not be too lengthy.
- The primary intent of the SWP is to institutionalize good safety practices.
- The Australian Standard (AS2211.1) and other Codes of Practice have information which may be useful in developing the SWP.
- The University Radiation Safety Officer will be happy to review and comment on the draft SWP.
- No one may undertake any work which involves lasers or laser systems without the person being trained (preferably attend a Laser Safety Course and annual refresher courses), the work approved, and both the user and the equipment registered.
- If the work involves chemicals then the full application of the Victoria Hazardous Substances Regulations and Code of Practice are to be applied and reference is to be made in the SWP.
- New users must be familiar with the Australian Standard AS2211.1-2004 and any relevant ARPANSA Codes of Practice.

5.2 Beam Alignments

- SECURITY - Secure the lab and (to avoid distractions) mark the door with the following sign: "NOTICE – Laser Alignment in Progress - DO NOT ENTER – EYE PROTECTION REQUIRED."
- PREPARATION - Locate all equipment and materials needed to perform the alignment prior to beginning the procedure.
- BEAM CHARACTERISTICS - Is the beam visible or invisible? Is special equipment needed to view the beam? If the beam is pulsed, can you fire a single pulse at a time to limit the exposure hazard?
- BEAM VIEWING - INTRABEAM VIEWING IS PROHIBITED ON THE CAMPUS and a remote viewing camera should be used if intrabeam viewing is required to align the beam. Only diffuse reflections should be viewed directly. Use a low power alignment laser (Class 2 or 3R) or if none is available, always use the lowest beam power which will allow viewing of an image with protective eyewear.
- PERSONAL PROTECTIVE EQUIPMENT - Use laser protective eyewear with a low enough Optical Density to allow viewing of the diffuse reflection (contact the University Radiation Safety Officer if you need information on alignment eyewear). Use skin covers (labcoat, gloves, and UV face shield) to protect users from UV laser beam scatter.
- PERSONNEL - Whenever possible, the "buddy" system must be used during alignments. If another person is not available to be in the room, let someone else know where you are and check in with them on a regular basis.
- EXPOSURE PRECAUTIONS - Keep the optical table clear of objects which may cause unwanted specular reflections. Always close the laser shutter while adjusting optics or when entering the beam path. After making adjustments, assure the optics are secured prior to opening the shutter.
- REPLACE BEAM CONTROLS - Ensure all beam blocks, enclosures, and beam barriers are replaced when the alignment is complete.
- CHECK DOOR SIGNS - Verify that the "NOTICE – Laser Alignment in Progress - DO NOT ENTER – EYE PROTECTION REQUIRED" sign is removed from the room entrance and that the regular Australian Standard laser warning sign is in place and correct.

5.3 Normal Operation of the Laser

- SECURITY - Do not rely upon a closed door as adequate security. Always use key locks or activate the door interlocks (if required by the Australian Standard – doors for Class 3B, 4, 2M & 3R lasers are to be interlocked) on the laser facility.
- The entrance to laser areas should be posted with standard laser warning signs, as per the entrance recommendations.
- OPERATIONAL PREPARATIONS - Indicate the location of the Laser Safety Guidelines posting. Indicate the equipment needed to perform the (laboratory specific) experiment.
- PERSONAL PROTECTIVE EQUIPMENT - Have the appropriate (laboratory specific) safety equipment on hand. Specify what is needed and its use.
- START-UP PROCEDURE - Insert key, turn on water, turn on power supply, close shutter, activate laser, etc. as specific to the laboratory.
- EXPERIMENTAL PROCEDURE - Specific to the laboratory.
- EMERGENCY PROCEDURE - Location of "PANIC" shutdown switch. Location of emergency procedure posting. Location of fire extinguisher, safety shower. etc.
- SHUT-DOWN PROCEDURE - Specific to the laboratory.
- STORAGE - Remove and store laser activation key, deactivate interlocks (if applicable) and secure door to laser facility.

5.4 Non-Beam Hazards to Address

- TOXICITY OF LASING MEDIA - Toxic laser dyes should be handled with labcoat, safety glasses, and gloves. Dyes should be mixed in a properly functioning fume hood and transported in sealed, leakproof containers. Dye pumps should sit in a secondary containment tray. Concentrated halogen gases (greater than 5%) should be used and stored in a properly functioning gas cabinet.
- ELECTRICAL HAZARDS - Only properly trained and approved personnel should work on high voltage systems. The "buddy" system should always be used when working on electrical systems and laboratory staff should be trained in CPR as a safety precaution.
- COMPRESSED GASES - Staff should be trained in the safe management of cylinders and the hazards associated with the specific compressed gases being used.
- FIRE PROTECTION - Attention should be given to protection against fires and explosions. Flammable solvents are often used for laser dyes and to clean optical components. Fire extinguishers should be well marked and staff should know how to use extinguishers and the fire alarm system.
- HOUSEKEEPING - Poor housekeeping (on and off the bench) can create physical hazards. Staff may trip over cables that have not been secured and injuries may result from sharp tools that are not properly stored.

5.5 Safety Associated with Servicing of the Laser

- Only approved and properly trained personnel should service laser systems. Vendor service staff are required to follow the vendor's laser safety policy. If University staff are assisting the service staff, the University staff must follow campus laser safety policy (eye protection, etc.).
- If University staff are to perform the service, a written service procedure with safe practice information must be available for reference (often the manufacturer will supply this information). All enclosures, interlocks, and safety devices (shutters, etc.) must be replaced and verified operational prior to returning the laser to service.
- Safety interlocks shall not be permanently disabled without the consent of the University Radiation Safety Officer.

6 Laser Safety Officer

The dean, head of school or director will nominate a Laser Safety Officer (LSO) where a faculty/school or division (department) uses Class 3 (i.e. Class 3R and 3B) or Class 4 lasers. The Laser Safety Officer is one who is knowledgeable in the evaluation and control of laser hazards. It should be the LSO’s responsibility to review the necessary precautions and designate the appropriate controls to be implemented.

Such deputies shall also be appointed as are necessary to ensure availability of expertise, taking into account leave and other absences.

The Laser Safety Officer coordinates the faculty, school or divisional compliance program. The Laser Safety Officers are responsible for:

- Oversight of the control of laser hazards.
- Reviewing the necessary precautions and designating the appropriate controls to be implemented for the safe use of lasers.
- Advising the department manager concerning local compliance with legislation/standards and providing managers, staff, students and others with advice on laser hazard management.
- Ensuring that when supervisors notify them of new laser equipment or modifications thereof to existing laser equipment, particulars of this equipment are entered on the register of laser equipment.
- Maintaining and regularly updating the budget centre's register(s) of laser equipment.
- Ensuring appropriate Safe Working Procedures (SWPs) and emergency procedures are available in each school, division or research centre where Class 3 (i.e. Class 3R and 3B) or Class 4 lasers are used. The SWPs must list the hazards associated with the particular lasers used in the area, the conditions under which they can be used and the precautions/control measures necessary to ensure safety.
- Advising and discussing with staff health risks peculiar to individual circumstances (for example, pre-existing eye disorders).
- The investigation together with local supervisor, OHS representative and University Radiation Safety Officer of any incidents involving lasers.
- Initially reviewing applications or proposals to carry out work using lasers.
- Ensuring laser hazard control facilities and containment arrangements are regularly inspected and reviewing inspection reports.

The Laser Safety Officer must be aware of legislation/standards covering the safety and safe use of laser products.

The Laser Safety Officer will suspend any activity involving laser use or laser processes in which there is an excessive or uncontrolled risk to any persons or where there is a breach of the legislation and relevant standards.

7 Training and Induction

Operation of laser systems can represent a hazard not only to the user but also to other people over a considerable distance. Because of this hazard potential, only persons who have received training to an appropriate level should be placed in control of such systems. The training, which may be given by the manufacturer or supplier of the system, the Laser Safety Officer, the University Radiation Safety Officer or by an approved external organisation, should include, but is not limited to:

a) Laser classifications and their hazard levels
b) Familiarisation with operating and safety procedures for use of the laser equipment
c) Hazardous bio-effects of the laser upon the eye and the skin
d) Other hazards (UV/IR/X-ray radiation, laser-material interactions, chemical, high voltage electricity etc.) incidental to laser operation.
e) The proper use of hazard control procedures, warning signs, etc.
f) The need for personal protection
g) Accident reporting procedures
h) Eye examination procedure required for operators of Class 3B and Class 4 lasers

All users of laser equipment are required to complete the online Working with Lasers at Deakin University laser safety information training and Checklist of Laser Hazard Control Procedures prior to their operation of the laser equipment.

See also Risk Assessments and Control Measures and Guidelines for Laser Safety 'Safe Working Procedures'

Refresher training is also required every 2 years. Training records must be kept for at least 5 years.

8 Medical Surveillance (Ref: AS 2211.1:2004)

In the absence of national regulations, the University has considered the following in requiring laser eye examinations for workers using Class 3B and 4 lasers:

- The value of medical surveillance of laser workers is a fundamental problem as yet unresolved by the medical profession. If ophthalmic examinations are undertaken, they should be carried out by a qualified specialist and should be confined to workers using Class 3B and Class 4 lasers.
- A medical examination by a qualified specialist should be carried out immediately after an apparent or suspected injurious ocular exposure. Such an examination should be supplemented with a full biophysical investigation of the circumstances under which the accident occurred.

Pre, interim and post employment ophthalmic examinations of workers using Class 3B and Class 4 lasers have value for medical legal reasons only and are not a necessary part of a safety programme. Please see the following procedure for organising laser eye examinations.

In view of the potential risks that may affect laser workers, the University requires that Faculties/Divisions provide the following medical examinations for laser workers working in their areas/departments:

- Appropriate laser eye examinations before commencement of work with Class 3B and Class 4 lasers and at the termination of employment or laser operations.
- Following any apparent or suspected laser radiation exposure. In this case, the eye examination should also be supplemented by skin examinations.
- Following any serious injury to, or illness of the eye.

8.1 Procedure for Organising Laser Eye Examinations

For the Geelong campus:

The laser eye examinations should be performed by optical practitioners and eye specialists at:

Kevin Paisley Fashion Eyewear,

Kevin Paisley Head Office,

269 Ryrie Street Geelong,

Geelong 3220.

Supervisors/managers can make appointments with Kevin Paisley's optical practitioners by phone or email (phone: (03) 5229 7144 , email: geelong1@kpspec.com.au) requesting appointment(s) and listing the name, Faculty/School and contact details of the staff who requires an appointment. The supervisor should also advise full details and address of the person and Faculty/Division/School to whom the invoice and a copy of the completed form and test results should be sent.

Personnel going for the laser eye examination appointment should bring with them a copy of the Form for Eye Examination and pass this to the optical practitioner or ophthalmologist carrying out the eye tests. Tests 1 to 5 in the form will be carried out and if ocular history and general health show no problems and the tests results are normal, no further examination is required. The fee for these preliminary tests is $25-00.

If there are any deviations from acceptable performance in the above tests during the appointment, the optometrist or ophthalmologist will continue to carry out additional tests (please refer Tests 6 to 10 on the form). The fees for these additional tests are about $60.00. Please note that the fees quoted are subject to change.

Please note that eye drops are used during the appointments that cause temporary blurriness or glare sensitivity so driving or detailed near tasks may be difficult for about an hour after the appointment. If people are driving they should bring sunglasses and be aware that they may need to wait an hour or so after the appointment before driving.

A copy of the completed tests or form should be sent to the Deakin University Radiation Safety Officer.

There is no requirement at this stage for any Warrnambool or Burwood staff to undertake eye tests. If the situation changes, please contact the Deakin University Radiation Safety Officer for further advice.

9 Laser Classification (Ref. AS2211.1:2004 and AS2211.10:2004)

Laser classification under AS/NZS 2211:2004 gives an indication of the degree of hazard for lasers. Class 1 being the least hazardous and Class 4 the most hazardous. Because of the wide ranges possible for the wavelength, energy content and

pulse characteristics of a laser beam, the hazards arising in their use vary widely. It is impossible to regard lasers as a single group to which common safety limits can apply.

To ensure all lasers manufactured prior to 2004 are easily identified, both the 2004 and 1997 standards are included for reference as follows:

9.1 Description of Laser Class (As per AS2211.1:2004)

Class 1: Lasers that are safe under reasonably foreseeable conditions of operation, including the use of optical instruments for intrabeam viewing.

Class 1M: Laser product in the wavelength range from 302,5 nm to 4 000 nm which does not permit human access to laser radiation in excess of the accessible emission limits of Class 1 for applicable wavelengths and emission durations. However, they are evaluated with smaller measurement apertures or at a greater distance from the apparent source than those used for Class 1 laser products. THE OUTPUT OF A CLASS 1M LASER IS THEREFORE POTENTIALLY HAZARDOUS WHEN VIEWED USING MAGNIFYING OPTICS OF ANY KIND.

Class 2: Lasers that emit visible radiation in the wavelength range from 400 nm to 700 nm where eye protection is normally afforded by aversion responses, including the blink reflex (assumed to take 0.25 seconds). The accessible emission limit (AEL) for Class 2 lasers is 1.0 mW for collimated beams or beams with small sources. As with all lasers, DO NOT LOOK INTO THE BEAM. The use of viewing optics such as binoculars with Class 2 laser products does not usually create a hazard as long as the objective lens diameter is not greater than 50 mm. Outside the wavelength range from 400 nm to 700 nm, any additional emissions of Class 2 lasers are required to be below the AEL of Class 1.

Class 2M: Lasers that emit visible radiation in the wavelength range from 400nm to 700nm where eye protection is normally afforded by aversion responses, including the blink reflex. HOWEVER, VIEWING OF THE OUTPUT MAY BE HAZARDOUS IF THE USER EMPLOYS OPTICS WITHIN THE BEAM OR VIEWS THE BEAM THROUGH MAGNIFYING OPTICS SUCH AS EYE LOUPES, BINOCULARS OR TELESCOPES.

Class 3R: Lasers that emit in the wavelength range from 302.5nm to 10^6nm where direct intrabeam viewing is potentially hazardous but the risk is lower than for Class 3B lasers, and fewer manufacturing requirements and control measures for the user apply than for Class 3B lasers. The accessible emission limits is within 5 times the AEL of Class 2 in the wavelength range from 400 nm to 700 nm and within 5 times the AEL of Class 1 for other wavelengths.

Class 3B: Lasers that are normally hazardous when direct intrabeam exposure occurs. The lasers are unsafe for eye exposure at all wavelengths, but are generally not so powerful that a short exposure would damage skin. Usually only eye protection would be required. Diffuse reflections are safe if viewed for less than 10 seconds.

Class 4: Class 4 laser products are generally powerful enough to burn skin and cause fires and may ionise the atmosphere when focused. As such, their use requires extreme caution and a range of additional safety measures are required. These lasers are also capable of producing hazardous diffuse reflections.

9.2 Description of Laser Class (As per AS2211.1:1997)

Class 1: Laser products which are safe under reasonably foreseeable conditions of operation. NOTE: The upper limits for Class 1 laser products are given in Table 1 (see Australian Standard AS2211.1:1997 and AS2211.1:2004) and are derived from the most limiting maximum permissible exposure (MPE) values, with allowance made for the possible concentration of energy by optical instruments.

Class 2: Laser products which emit visible radiation in the wavelength range from 400 to 700 nm. Eye protection is normally afforded by aversion responses including the blink reflex.

Class 3A: Laser products which emit higher levels of radiation and require more stringent precautions than those necessary for Class 2 laser products. They differ from Class 2 laser products in that they emit more power in a

beam of larger cross-section, so that when the output is directly viewed, the power of the beam entering the eye does not exceed that of a Class 2 laser product (the pupil diameter is assumed to be 7 mm). However, if the beam is viewed through larger diameter collecting optics (e.g. binoculars) then the hazard is usually increased. For continuous wave (CW) output in the visible wavelength range (400 nm to 700 nm), the output power is limited to 5 mW and the maximum irradiance is 25 $Wm^{-2.}$

Class 3B (Restricted) : Laser products which operate at the same power levels as Class 3A laser products, but have higher levels ($\leq$ 50 Wm^{-2}) of irradiance (power density). They may be used in daylight conditions, where the pupil diameter will be not greater than 5 mm, under the same controls as for Class 3A laser products. Where used in conditions of lesser illuminance, (in general this is less than approximately 10 lux), the appropriate safety controls are those specified for Class 3B laser products.

Class 3B: Laser products which emit either invisible or visible radiation and direct viewing is hazardous to the eye. Class 3B laser products are capable of causing eye injury either because their output is invisible and therefore aversion responses are not activated, or because the beam power is such that damage is done in a time shorter than the blink reflex (0.25 s). Higher power laser products in this class may also cause skin burns. However, with laser wavelengths other than those in the ultraviolet region, the pain produced by rapid heating of the skin will usually evoke an aversion response sufficient to avoid such burns.

Class 4: High power laser products with output powers exceeding the AELs specified in Table 4 (See Australian Standard AS2211.1:1997) for Class 3B. All Class 4 laser products are capable of producing hazardous diffuse reflections. They may cause skin injuries and could also constitute a fire hazard. Their use requires extreme caution.

10 References and Other Supporting Documents

Australian Standard AS/NZS 2211.1:2004 *'Safety of Laser Products. Part 1: Equipment Classification, Requirements and User's Guide'*

Australian Standard *AS/NZS 2211.10:2004 'Safety of Laser Products. Part 10: Application Guidelines and Explanatory Notes to AS/NZ 2211.1'*

Australian Standard AS/NZS 2211.1:1997 *'Safety of Laser Products. Part 1: Equipment Classification, Requirements and User's Guide'.* Superseded by AS/NZS 2211.1:2004 above, but provides reference to old laser classifications etc. for some laser equipment in use.

Australian Standard *AS/NZS 2397:1993 'Safe Use of Lasers in the Building and Construction Industry'.*

Australian Standard *AS/NZS ISO 11553:2004 'Safety of Machinery – Laser Processing Machines – Safety Requirements'*

Australian Standard *AS/NZS 1336:1997 'Recommended Practices for Occupational Eye Protection'*

Australian Standard *AS/NZS 1336:1997/Amendment 1:1997 'Recommended Practices for Occupational Eye Protection'*

Australian Standard AS/NZS 2211.4:2002 *'Safety of Laser Products. Part 4: Laser Guards'*

Australian Standard AS/NZS 2211.2:2006 *'Safety of Laser Products. Part 2: Safety of Optical Fibre Communication Systems (OFCS)'*

Charles Sturt University '*Radiation Safety Manual*'

Melbourne University, School of Physics, '*Laser Safety Manual'*

University of Wollongong '*Laser Safety Guidelines'*

Monash University *'Laser Pointer and Controlled Weapons Information Sheet'*

University of Western Sydney '*Radiation Safety Guidelines'*

University of Queensland '*Laser Safety Guidelines'*

Berkeley University '*Laser Safety Program'*

ARPANSA '*Code of Practice for the Safe Use of Lasers in Schools (1995) Issued by NHMRC'*

ARPANSA, Radiation Basics, Lasers, available at: http://www.arpansa.gov.au/radiationprotection/basics/laser.cfm.