LASER EQUIPMENT

1. The University has appointed a Laser Protection Adviser (LPA) under an agreement with NHS Grampian Radiation Protection Service to ensure that the University arrangements for laser safety are followed. The LPA will ensure that arrangements are in place for identification of lasers and users of equipment, inspection of all new laser facilities, routine auditing of laser facilities and training of staff for laser safety.

For each class 3 or class 4 laser facility a Laser Protection Supervisor (LPS) must be appointed in consultation with the LPA.

The School of Engineering has additionally appointed a Lead Laser Protection Supervisor (LLPS) to advise, train and support the School's LPSs and to Liaise with the University's LPA.

Before introducing new laser equipment, or changes to existing systems should discuss this first with the School of Engineering's LLPS.

Any member of the School who has any doubt as to his or her duties regarding laser safety or has any concern regarding laser related safety matters should contact the LLPS or the University's LPA.

2. Laser Protection Supervisor

For each laser facility where Class 3 or Class 4 lasers are used, a Laser Protection Supervisor must be appointed if the University's LPA considers it is necessary. The appointment must be confirmed in writing. Laser Protection Supervisors are responsible for the safe use of the laser in the area specified in their appointment letter. They must bring the local rules and Safe Operating Procedures to the attention of all staff affected by them. Any compromises in safety must be reported to the LPA or the University HS&W Team. The LPS is responsible for the safe keeping of the laser keys and must issue the keys only to an authorised user. The LPS should perform the quality assurance checks as specified in the local rules.

3. Responsibilities of Research Supervisor/Principal Investigator

The day-to-day health and safety management of individual research projects is normally the responsibility of the research supervisor/principal investigator. It is appropriate that they have the responsibility for ensuring any laser equipment brought in is fit for purpose and safe to use. They should seek the advice and guidance of the LPS, LLPS or LPA, to put in place adequate risk assessments and controls for safe systems of work.

The Research Supervisor/PI should ensure that:

- The LLPS and LPA is informed of the intention to buy a laser system or bring one on site prior to its purchase or loan and arrival.
- All work involving hazardous lasers must be covered by risk assessments and Standard Operating Procedures.
- The design of the laboratory, laser type, experimental setup and access controls (e.g. interlocks) must be considered as part of the risk assessment, SOPs.
- There should also be procedures to ensure that lasers are made safe prior to disposal and dealt with appropriately if they contain hazardous materials.
- Laser users are effectively trained in the operating techniques required.
- Inexperienced staff are adequately supervised.

- The safety of cleaners, security or maintenance staff inadvertently accessing or disturbing equipment must also be addressed.

4. Responsibilities of Laser Users

Laser users also have responsibilities:

- To observe the Policy, guidance and SOPs applicable to the lasers that will be used, and to follow the guidance of supervisors and the LPS.
- Not to leave a laser experiment running unattended unless a risk assessment has established that it is safe to do so.
- For their own safety and that of others who may be affected by their acts or omissions.
- When working with Class 3 or Class 4 lasers there is the possibility of stray laser beams that could damage the eyesight; where required and provided for use, the appropriate laser eyewear must be worn as instructed.

5. New Installations or Modifications to Laser Systems.

The Schools LLPS must be informed of any:

- Planned introduction.
- Change of use.
- Modifications or upgrading.

of laser equipment so that:

- A risk assessment can be made.
- Hazards identified.
- Controls put in place.

before the intended use commences.

The University's Laser Protection Adviser must be satisfied with safety arrangements and, for new installations, consulted for the appointment of an appropriate Laser Protection Supervisor.

6. Laser Classification

A system of laser classification is used to indicate the level of laser beam hazard as it emerges from the laser product and maximum Accessible Emission Levels (AELs) have been determined for each class of laser. The previous classification system, which was based on a system of seven classes (1, 1M, 2, 2M, 3R, 3B & 4), now consists of eight classes (1, 1M, 1C, 2, 2M, 3R, 3B & 4) and these are described below:

Class	Description
1	Lasers that are safe under reasonably foreseeable conditions of operation, either because of the low emission of the laser itself, or because of its engineering design such that it is totally enclosed and human access to higher levels is not possible under normal operation. A laser that emits laser radiation below the Class 1 AEL under all conditions of operation and failure is exempt from most of the requirements of the standard. Note: If access panels of a totally enclosed system are removed for servicing etc. then the laser product is no longer Class 1 and the precautions applicable to the embedded laser must be applied until the panels are replaced. It is

	important that when such systems are installed in open laboratories, the potential for this should be considered prior to first installing the system.
1M	Laser products emitting in the wavelength range 302.5 nm to 4000 nm, whose total output is in excess of that normally permitted for Class 1 laser products but because of their very low power density do not pose a hazard in normal use and comply with the measurement conditions for a Class 1M product. However they may be hazardous to the eyes under certain conditions if gathering optics are used with them, i.e. a) With a diverging beam if optics are placed within 100 mm of the source to concentrate/collimate the beam (this condition only applies to communication lasers). b) With a large diameter collimated beam viewed with binoculars or a telescope.
1C	Any laser product which is designed explicitly for contact application to the skin or tissue and that: a) 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 tissue. b) 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. c) The laser product complies with applicable vertical (product-specific) standards
2	Lasers that only emit visible radiation in the wavelength range from 400 nm to 700 nm and whose output is less than the Class 2 AEL. They are safe for accidental viewing as eye protection is afforded by aversion responses, including the blink reflex. This reaction may be expected to provide adequate protection under reasonably foreseeable conditions of operation including the use of optical instruments for intrabeam viewing.
2M	Laser products that only emit visible radiation in the wavelength range 400 nm to 700 nm, whose total output is in excess of that normally permitted for Class 2 laser products but because of their very low power density are safe for accidental viewing during normal use and comply with the measurement conditions for a Class 2M product. However they may be hazardous to the eyes under certain conditions if gathering optics are used with them, i.e., a) With a diverging beam if optics are placed within 100mm of the source to concentrate/collimate the beam (this condition only applies to communication lasers). b) With a large diameter collimated beam viewed with binoculars or a telescope.
3R	Lasers that emit in the wavelength range from 180nm to 1mm 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. The AEL is restricted to no more than five times the AEL of Class 2 for visible wavelengths and no more than five times the AEL of Class 1 for other wavelengths.
3B	Lasers that are normally hazardous when direct intrabeam exposure occurs (i.e. within the Nominal Ocular Hazard Distance (NOHD), which is the distance within which the beam irradiance or radiant exposure will exceed the

	appropriate MPE). Viewing diffuse reflections is normally safe. Output levels must be less than the appropriate AELs for Class 3B devices.
4	High power lasers that exceed the AELs for Class 3B products that are also capable of producing hazardous diffuse reflections. They may cause skin injuries, could also constitute a fire hazard and could cause hazardous fumes to be produced as well as being a hazard to the eyes. Their use requires extreme caution.

7. Hazards Associated with Lasers

Class 3 and Class 4 lasers can cause eye injuries and skin/body injuries (e.g. burns and potentially deep penetration). They can produce hazardous fumes and constitute a fire risk.

Eye hazards can be significant and the first, and perhaps the most important, factor in determining a laser's eye hazard potential is its wavelength. Wavelength determines which part of the eye absorbs the radiation and whether the radiation can be focused by the eye.

Because the eye is much more susceptible to damage from laser radiation than other parts of the body, **skin hazards** have not been emphasized as much. However, repeated, or even a single, exposure to certain laser wavelengths can cause skin damage of varying degrees.

Exposure to a laser beam may occur in several ways:

- **Direct exposure:** occurs when one is in the direct path of the laser beam or in the path of a beam reflecting off a mirror-like object.
- **Indirect exposure:** occurs when a beam is scattered before it reaches the eye or skin. The material scattering the laser energy may be a rough, nonreflective surface, such as a brick wall, or it may be small, airborne particles, such as dust or water vapor. During indirect exposure, the beam's energy dissipates rapidly as one moves away from the material that caused the scatter.

Non-beam hazards associated with laser include:

- Build-up of assistant gasses such as nitrogen or CO_2 in an enclosed space.
- Unprotected wiring and tubing.
- Unposted or improper warning signs.
- Improper fume exhaust systems.
- Defeated interlocks.
- No lockout provisions.
- Lack of data on toxicity of chemicals and fumes (No material safety data sheets [MSDS] information).

8. Precautions for Class 3 and Class 4 Lasers

By default, the beam from Class 3 and Class 4 lasers should be enclosed. Open beam work should be by exception only and must be supported fully by a justification.

For Class 3 or 4 lasers, each laser laboratory or experiment, as appropriate, should have its own Standard Operating Procedure (SOP) based upon the conclusions of a risk assessment. The SOP should include: the name of the LPS, list of authorised users, the extent of any laser designated area, and references to any specific protocols that are to be followed. The SOPs should be displayed in a prominent position or readily available within a laboratory folder.

Controls for the laser radiation hazard include:

- Remote interlock facility.
- Safety interlocks in protective housing.
- Key control.
- Emission warning device.
- Beam stop or attenuator/shutter.
- Terminating the beam at the end of its useful path.
- Avoiding beam paths at eye level and where practicable enclose the beam.
- Beam enclosure.
- Eye protection.
- Protective clothing.
- Eye examinations.
- Laser labels.
- Door/Area signs.
- Instruction and training to an appropriate level.

Hazards (other than from laser radiation) that can be found in the laser area must also be adequately assessed and the risks controlled. Non-optical hazards might include:

- Electrical (high voltages).
- Collateral radiation.
- Fumes.
- Fire and explosion.
- Mechanical hazards.
- Noise.

Other hazards may also arise from the environment in which the laser is used. For example: adverse temperature and humidity, low light-level conditions, mechanical shock and vibration, interruptions to the power supply, computer software problems and ergonomic problems.

9. Eye Protection

Whenever there is a risk of laser exposure, personal eye-protection is essential. Laser protective eyewear should never be relied on to provide protection against deliberate exposure to a laser beam but should be regarded as a means of providing some protection against accidental exposure. Protective eyewear should be adopted only after a full safety evaluation has been carried out and other means of affording protection (proper engineering controls) have been considered and rejected.

Special attention has to be given to the resistance and stability against laser radiation when choosing eyewear or protective clothing for protection against Class 4 lasers.

10. Laser Area Controls

Laser area controls include dedicated enclosure, curtains, barriers and access control.

The points of access to areas in which Class 4 lasers are used must be marked with warning signs.

Curtains and barriers provide the flexibility over a dedicated enclosure for working in different areas. Movable barriers can be obtained with a door entry and warning system.

For high power lasers barrier and screens can provide a higher level of protection for multi-KW lasers.

When selecting curtains and barriers care must be taken to ensuring the compatibility with the laser equipment and the likely power level it is required to withstand.

11. Emergency Procedures

Minor Injuries: A first aider should be contacted and asked to assist and the individual instructed to report to Aberdeen Royal Infirmary within 24 hours.

Major Injuries: The following procedure when calling for an ambulance:

- Dial 9-999 (or 112 from mobile).
- Know the Address you are calling from.
- Know the Phone Number you are calling from.
- Know what has happened.
- Additional Information.
    - Patient's age, gender and medical history.
    - Whether or not the patient is conscious, breathing and if there is any chest pains or bleeding.
    - Details of the injury and how it happened.

Someone should then be sent to the front door of the building to look out for and direct the ambulance. A first aider should be contacted to administer first aid to the casualty while waiting for the ambulance to arrive.

The medical team may request further information that might include:

- Laser Type and classification.
- Wavelength.
- Power Output (or pulse energy/duration/rate).
- Any PPE being worn at the time of the incident.

Serious accidents should be reported to the Health, Safety and Wellbeing Team immediately by telephone.

For an out of hours incident Security Control should be contacted on their Emergency Number.

All incidents must be reported within 48 hours completing an accident or near-miss report form. This should be undertaken by the immediate supervisor of the injured person or the person in charge of the area where the incident happened.

Revision Record			
Issue	**Name**	**Date**	**Reason for review**
1	ES	31/5/2022	Transfer from main handbook
	ES	26/8/2022	Added alt text for images