University of St Andrews

Policy and guidance on work with lasers and high powered artificial optical radiation

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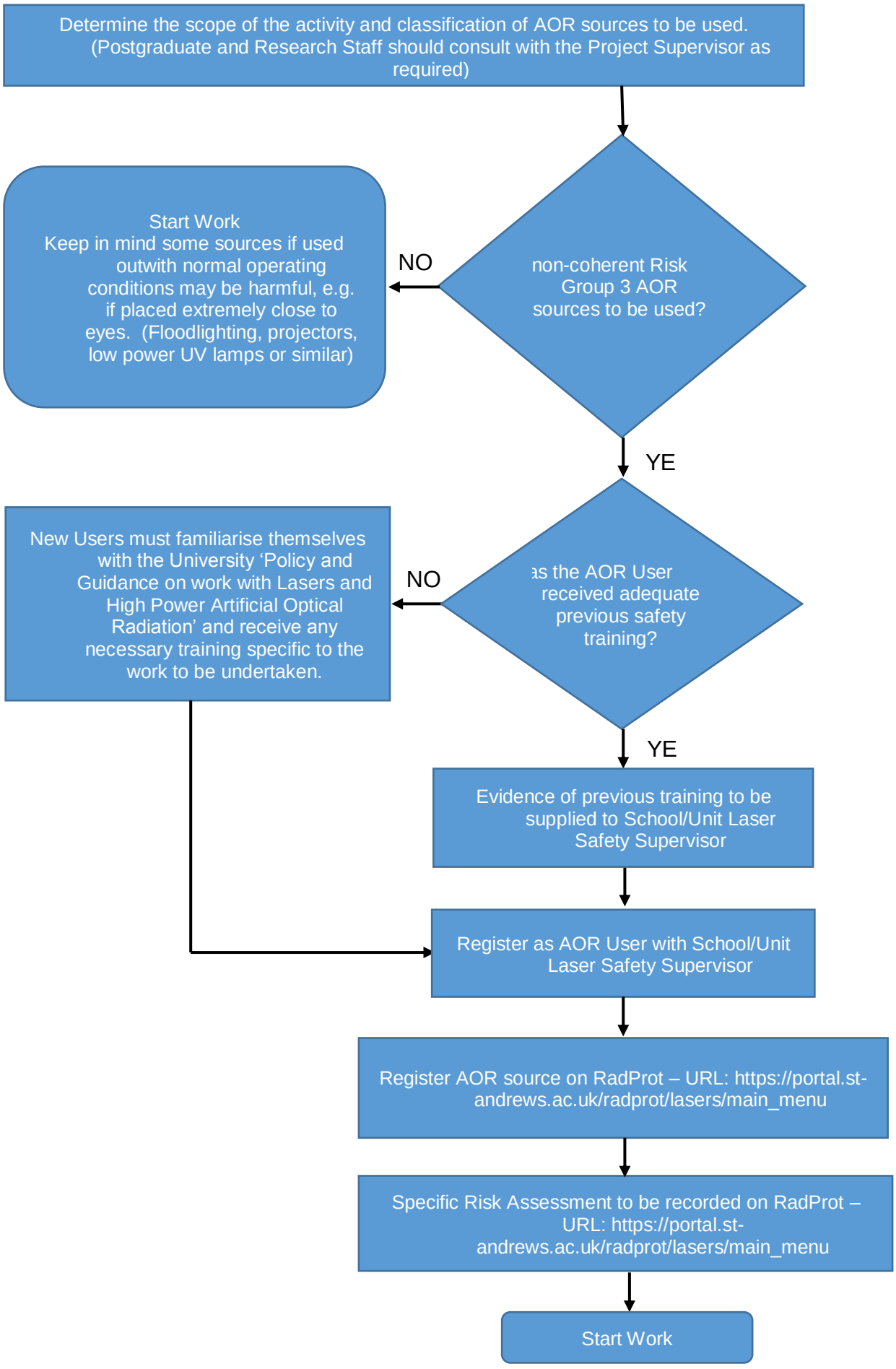
Policy and Guidance on Work with Lasers and High Power Artificial Optical Radiation

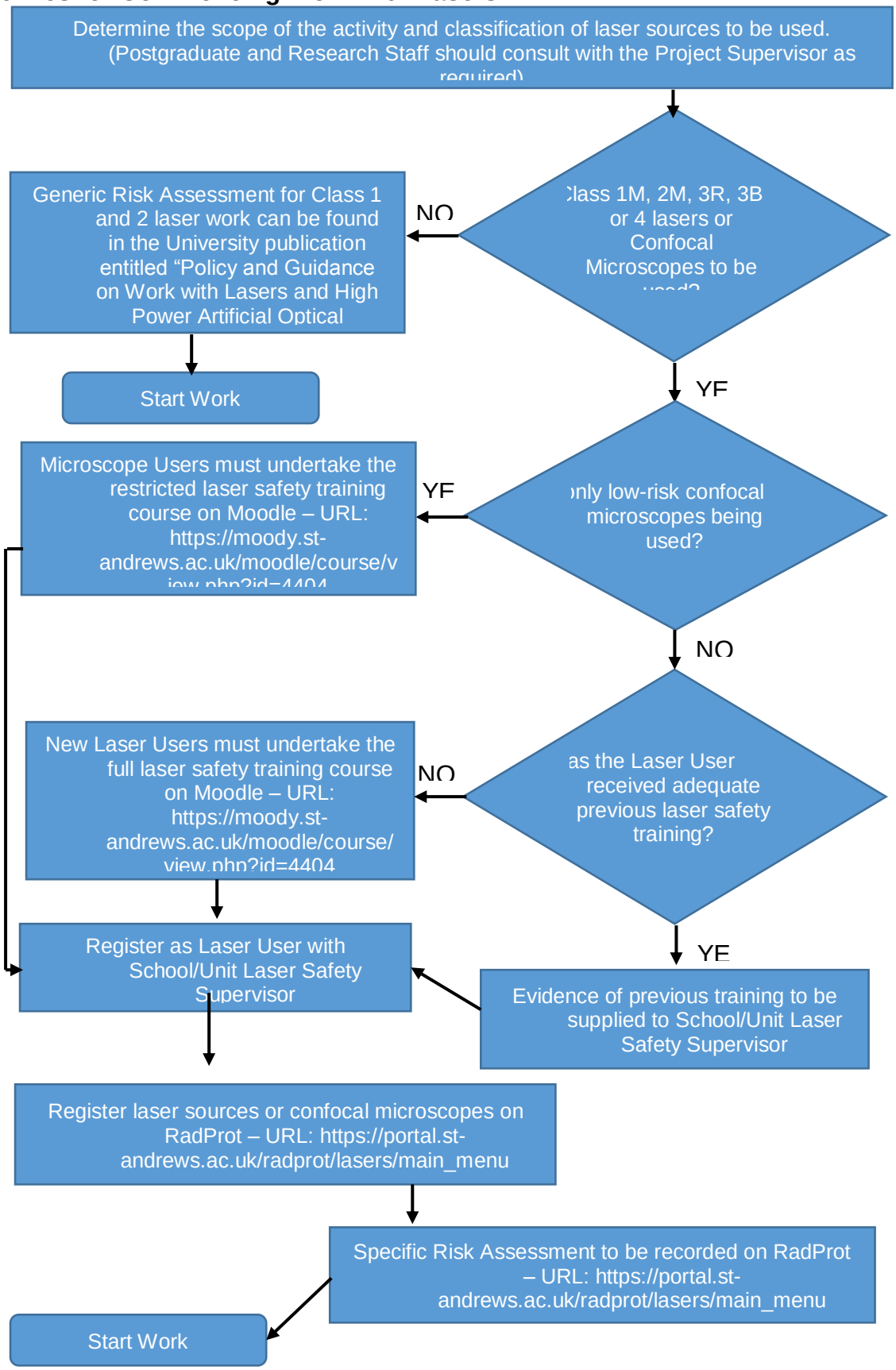
Contents

Appendices

Guidelines for Commencing Work with Artificial Optical Radiation (AOR) - Non-Laser Work



Guidelines for Commencing Work with Lasers



1. Introduction

Coherent light sources (e.g. lasers) and other high power optical radiation sources, e.g. light emitting diodes (LEDs), can generate significant quantities of power over small areas and at significant distances from the light source. As a consequence there are potential risks associated with the use of such equipment. These include the risk of fire, thermal injuries to the eyes and skin as well as photochemical reactions in the eye and skin.

There is specific legislation for work with high power optical radiation, which is 'The Control of Artificial Optical Radiation at Work Regulations 2010'. This legislation requires the employer to determine if there is a significant risk of injury or harm to an employee due to artificial optical radiation, which includes the use of lasers and non-coherent light sources such as high power LEDs. A suitable and sufficient risk assessment must then be carried out and appropriate control measures implemented to eliminate or minimise the risk of injury.

The British Standard BS TR 60825 - Part 14 (2004) gives specific details on laser safety good practice and BS EN 62471: 2008 for the categorisation of all artificial optical radiation. The following guidance is based on these documents, as well as that of the Health and Safety Executive (HSE) and Association of University Radiation Protection Officers (AUPRO).

This document will provide a statement of the University policy on work with lasers or high power artificial light sources and also guidance on safe working practices. Further guidance on safe working practices can be found on the EHSS Moodle site at URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=4404

2. Policy Statement

The following is the University of St Andrews Policy Statement with respect to work with lasers or high power artificial light sources. At all times, reference to artificial optical radiation (AOR) includes laser sources, although in places more specific detail relating to work with lasers is included.

1. This University will comply, as far as reasonably practicable, with all legislation with regard to the safe use of artificial optical radiation.
2. The Office of the Principal has ultimate authority for regulating work with artificial optical radiation within the University.
3. The Head of School/Unit has the responsibility for ensuring this policy is implemented within their School/Unit.
4. All supervisors of those working with artificial optical radiation have a duty to ensure the workers under their control comply with this policy and guidance.
5. All employees have a duty to ensure their safety and the safety of others by their acts and omissions when working with hazardous artificial optical radiation.
6. A suitably qualified University Laser Safety Adviser will be appointed to provide advice to staff and students as well as to the Office of the Principal on laser hazard issues.
7. All staff and students of the University of St Andrews making use of lasers, except Class 1 and Class 2 devices, as part of their activities relating to their University employment/studies must complete the University's Laser Safety Training Course prior to starting work with such devices. For the avoidance of doubt, this includes work both on and off University premises (see URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=4404).
8. All visiting staff and students making use of lasers, except Class 1 and Class 2 devices, on University premises must have received adequate laser safety training prior to starting work with such devices.

9. All hazardous optical radiation sources (lasers Class 1M, 2M, 3R, 3B, 4 and other Risk Group 3 artificial optical radiation sources) must be registered on the University radiation management programme called 'RadProt' (see URL: https://portal.st-andrews.ac.uk/radprot/open/).
10. Suitable and sufficient risk assessments for the use of hazardous optical radiation sources must be produced and a copy registered with the University Laser Safety Adviser using the RadProt Radiation Management Programme (see URL: https://portal.st-andrews.ac.uk/radprot/open/).
11. All open beam Class 3B and Class 4 lasers must be operated in an enclosed system or in a room with an interlock linked to the room access door(s).
12. An annual inspection of all hazardous optical radiation sources and associated facilities will be undertaken by each School/Unit.
13. Artificial optical radiation safety issues will be discussed at a University Radiation Hazards Management Group, which will be convened by the Director of EHSS and the University Radiation Protection Adviser will be a member.
14. Minutes of the University Radiation Hazards Management Group will be sent to the Vice-Principal for Research at the Office of the Principal.
15. A specific detailed risk assessment will be undertaken for new and expectant mothers who may work with hazardous optical radiation.
16. All accidents/incidents from work with artificial optical radiation will be reported to the Director of EHSS.
17. Where the University Occupational Health Adviser believes it is appropriate, suitable health surveillance will be provided to those working with Class 3B and Class 4 open beam high power laser sources and Risk Group 3 artificial optical radiation sources.
18. All laser pointers used in the University will be less than 1mW in power. To ensure this, all such laser pointers must be tested by the University Laser Safety Adviser prior to use.

The reporting structure between the bodies noted within this policy can be found in Appendix 1.

3. Arrangements for Managing the Use of Lasers and High Power Artificial Optical Radiation

The structure of the management system for Health and Safety is given in the University 'Health and Safety Policy' (2017). This can be viewed at the following website: http://www.st-andrews.ac.uk/media/Approved HS Policy Final.pdf

It is the policy of the University to, so far as reasonably practicable, ensure the health safety and welfare of staff / students at the University and of those who may be affected by this work.

Thus, it is the policy of this University that all work with high power artificial optical radiation (AOR), including lasers, is carried out in such a manner as to prevent undue risk to those performing the work or put others at risk due to their actions or omissions.

This document will describe the arrangements the University has put in place to manage such safety.

Work with AOR, including lasers, should only be carried out if a suitable assessment of the risks of the work are identified and that appropriate control measures are implemented to eliminate or minimise the risks of the hazards. This guidance will provide practical information on how risk assessments on work with artificial optical radiation, including lasers, can be performed and the actions which should be taken to minimise these risks.

Staff and students have a responsibility to take care of their own health and safety with respect to the use of AOR and that their acts or omissions do not endanger the health and safety of others. Workers also have a responsibility to comply with any instructions provided by management regarding such safety matters.

3.1 The Radiation Hazards Management Group

This Management Group reports to the Principal's Office and to the Health Assurance Group of the Risk and Audit Committee of Court. The Group is responsible for monitoring radiation safety at the University and is also responsible for reviewing radiation safety policies including that for AOR safety policy for the University. These policies must be complied with in Schools/Units.

The Radiation Hazards Management Group is responsible for ensuring University policies are being complied with and it does this by undertaking appropriate safety audits.

This Management Group oversees the work of the University Radiation Protection Service.

Membership of the Radiation Hazards Management Group is given in Appendix 2.

3.2 The University Laser Safety Adviser

The University Laser Safety Adviser provides specialist advice on laser safety to the Radiation Hazards Management Group, senior managers of the University, Heads of Schools/Units and School/Unit Laser Safety Advisers) and to laser workers on request. The remit of the University Laser Safety Adviser is given in Appendix 3.

3.3 Responsibilities of the Head of School

The Head of School / Unit must ensure that University laser and high power AOR safety policies are implemented and being complied with in their area of control.

The Head of School/Unit or a nominated depute should ensure that an appropriate annual inspection of AOR, including laser, safety is carried out.

Where hazardous AOR sources are used, should appoint a School/Unit Laser Safety Supervisor. The person appointed should have suitable experience, knowledge about the physics of lasers and the biological effects of laser radiation on tissues.

3.4 School / Unit Laser Safety Supervisor

The remit of this post includes:

- Advise the Head of School/Unit on matters relating to laser safety and other forms of AOR.
- Provide AOR safety advice to Heads of Research Groups, Research Staff/Students, Teaching Lab Personnel and other Laser Workers within the School.
- Make available appropriate training in laser safety to University Laser Workers based within the School/Unit.
- Make available for consultation current Codes of Practice, Guidelines and other literature.
- Assist (the University Laser Safety Adviser and University Safety Office) in the reporting and investigation of suspected AOR accidents and near misses and ensure that appropriate medical advice has been sought after such incidents.
- Carry-out annual AOR safety audits in conjunction with University Laser Safety Adviser on behalf of the Radiation Hazards Cub-committee and report findings/actions to Heads of Research Groups, Head of School/Unit and Radiation Hazards Cub-committee.
- Ensure that all work involving hazardous AOR (lasers Class 1M, 2M, 3R, 3B, 4 and other Risk Group 3 AOR) within the School/Unit is risk assessed.
- Ensure that all hazardous AOR sources (lasers Class 1M, 2M, 3R, 3B, 4 and other Risk Group 3 AOR sources) are registered with the School/Unit.
- Ensure all users of hazardous AOR are registered within the School/Unit.
- Maintain records of School/Unit; Registered Laser Users, Lasers and Risk Assessments.
- Provide AOR safety input to School/Unit Safety Committee meetings.

3.5 Laser Users

Each ‘Laser User’ has a responsibility for their own safety while using lasers and should not put others at risk by their acts or omissions when using lasers.

All users of lasers which pose a significant risk should be registered with the School/Unit and undergo appropriate laser safety training. This means all users of Class 1M, 2M, 3R, 3B and 4 lasers. Where the laser is totally enclosed and the beam inaccessible, then the equipment is classed as Class 1 equipment even though it may contain a Class 4 laser (see Section 8). Where access to a Class 3B or Class 4 laser in Class 1 equipment may be envisaged in the presence of a laser user, for example during servicing or realigning, the laser user should undergo specific training and must be registered with the School/Unit.

It is, also, the responsibility of laser users to:

- Register as a Laser User with the School/Unit Laser Safety Supervisor using the form in Appendix 4 and available also on-line on the EHSS Website.
- Ensure the laser(s) they intend to use are registered with the School/Unit Laser Safety Supervisor.
- Undergo appropriate laser safety training, (this should be carried out before work starts) to be found in the University's Laser Safety Moodle Course, including:
    - Read the University Policy and Guidance on Work with Lasers and High Power Artificial Optical Radiation (this document);
    - Viewing, where appropriate, the LIMITS laser safety training software;
    - Acquaint themselves with the School/Unit precautions and procedures for managing laser safety, including undertaking effective risk assessments.
- Discuss the work they propose to undertake with their School/Unit Laser Safety Supervisor prior to the work starting;
- Comply with relevant laser safety instructions issued by the University and by the School/Unit.

3.6 High Power (Risk Group 3) Artificial Optical Radiation Source Users

Each high power AOR user has a responsibility for their own safety while using AOR sources and should not put others at risk by their acts or omissions when using AOR sources.

It is the responsibility of AOR users to:

- Register as an AOR User with the School/Unit Safety Coordinator or School/Unit Laser Safety Supervisor using the form in Appendix 4
- Ensure the AOR sources they intend to use have been registered with the School/Unit Safety Coordinator or Laser Safety Supervisor.
- Undergo appropriate safety training, (this should be carried out before work starts), including:
    - Read the University Policy and Guidance on Work with Lasers and High Power Artificial Optical Radiation (this document);
    - Acquaint themselves with the School/Unit precautions and procedures for managing AOR safety, including undertaking effective risk assessments.
- Discuss the work they propose to undertake with their School/Unit Safety Coordinator or Laser Safety Supervisor prior to the work starting;
- Comply with relevant safety instructions issued by the University and by the School/Unit.

3.7 School / Unit Artificial Optical Radiation Hazards Policies

Where there is the use of Risk Group 3 AOR sources within a School/Unit, the local health and safety policy should include details on the identification and control of risks associated with the use of these sources within the School/Unit. In compliance with University policy the School/Unit policy should ensure:

- Implementation of the University Policy on controlling AOR, which requires that a suitable and sufficient risk assessment should be performed. This should be recorded on the University radiation management programme RadProt. All such risk assessments should be signed by all relevant people before any work can be initiated;
- The systematic elimination or reduction of risks from AOR;
- The control of exposure to AOR by means other than Personal Protective Equipment (PPE);
- That, where appropriate, a suitable maintenance regime is implemented for mechanical control measures (for example interlocks on doors where there is work with an open beam Class 3B or 4 laser);

- That where appropriate, suitable guidance is produced for the selection, issue, use and maintenance of specialised Personal Protective Equipment (PPE) used for work with open beam lasers and high power AOR;
- That suitable and sufficient information, instruction, training and supervision for the use of Class 1M, 2M, 3R, 3B and 4 lasers and high power AOR is provided;
- that regular reviews of risk assessments are carried out;
- that regular reviews of the School/Unit arrangements for the compliance are carried out.

3.8 Environmental, Health and Safety Services

EHSS will provide support to the University Laser Safety Adviser, and will administer the RadProt programme. The Director of EHSS will be involved in monitoring laser safety with inspections and audits with the University Laser Safety Adviser.

3.9 Intended Audience

This policy and the attached guidance are intended for all members of staff and students at the University who use hazardous AOR sources as a requirement of their work/study activities.

3.10 Where these Regulations apply

This policy and guidance is applicable for all Schools/Units within the University where hazardous AOR sources are being used.

4. Legislative and Regulatory Framework

4.1 Legislative Framework

This policy and guidance document has been produced to ensure compliance with the following legislation:

- Health and Safety at Work Act 1974 – This is the general legislation which all health and safety regulations are derived from;
- Control of Artificial Optical Radiation at Work Regulations 2010 – This legislation has been enacted to ensure the health of workers, notably to protect against skin and eye injuries, when using high power artificial optical radiation, including laser sources;
- Control of Substances Hazardous to Health Regulations 2002 as amended – This legislation has been enacted to ensure the health of workers when using hazardous substances, which includes chemicals, biological agents, dusts. The legislation includes dealing with any hazardous substances used in the making or potential use of AOR sources;
- The Personal Protective Equipment at Work Regulations 1992 as amended – This details the processes for choosing, using and maintaining personal protective equipment, which includes eye protection when using high power AOR;
- Management of Health and Safety at Work Regulations 1999 – Requirement to undertake appropriate assessments where there is a significant risk.

4.2 Relationship with existing University Policy, Procedures and Regulation

As noted throughout this Policy, compliance with the conditions set out here will on occasion also require observance of other University Policy and Regulations referred to herein.

Guidance

5. Biological Effects of Optical Radiation

5.1 Biological Effects of light

The two major effects on biological tissue of lasers and non-coherent artificial light are thermal injuries and photochemical type injuries.

Thermal injuries occur when the tissue is heated to above 60^{o}C causing cell death and if heated sufficiently causes carbonisation of the tissue. This type of injury is non-cumulative in nature, thus either a very high power laser or a long continuous exposure period to a low power laser or other artificial light source is required to cause such an injury. This type of injury is more common with the non-visible wavelengths as the eye aversion response is not present.

Photochemical injuries are caused by the light inducing chemical reactions in the biological tissue. This type of injury is strongly wavelength dependent and depends on the accumulated radiant exposure (Jm^{-2}). This means that the effects of exposure are cumulative over time.

5.2 Laser Induced Injuries to the Eye

The eye is made up of many parts each with different sensitivities to the various wavelengths of light produced by lasers (see Figure 1 and Table 1).

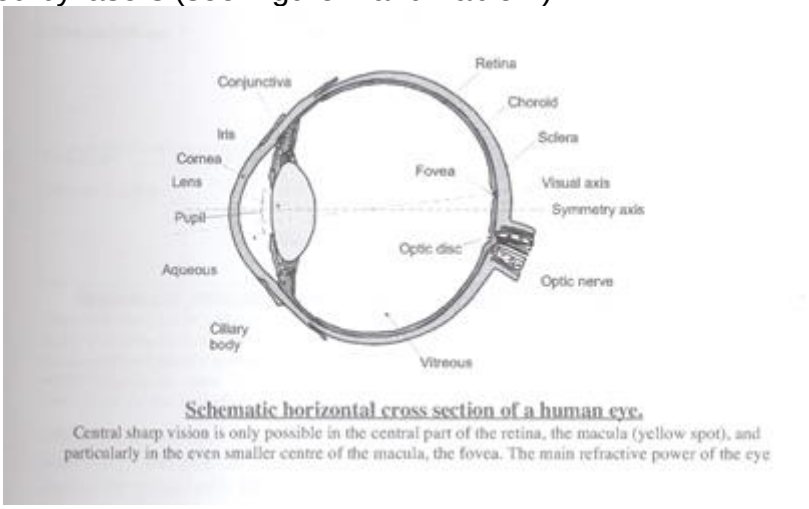


Figure 1: Main Components of the eye. [Courtesy of Pro Laser Consultants.]

Damage to the eye by laser radiation can be permanent as specific regions of the eye cannot be regenerated, e.g. the lens and retina.

The damage caused to the eye is dependent on the wavelength of the light, the length of time exposed to the beam and the pulsed or continuous wave nature of the laser, for example some pulsed lasers have very high peak power pulses of light over very short periods.

Wavelength Range	Tissue Affected	Short Pulse Injury	Long Exposure (over several seconds or more) from Continuous Wave (CW) and Repetitively Pulsed Lasers
Ultraviolet (180 nm to 400nm)	Cornea and lens	Thermal damage dominates. Denaturation (clouding) of cornea and at 280nm - 400 nm lens. ***Short Pulses -*** Photoablation of corneal tissue with high power pulses	Photochemical damage dominates. Photokeratitis (‘arc-eye’ or ‘snow blindness’) of the cornea. Photochemical cataract (at 280nm to 400nm).
Visible and Near Infrared	Retina	Thermal damage dominates. Burn (protein degradation) with severe vision loss when damage in the foveal region of the eye. ***Short Pulses -*** Photochemical damage i.e. rupture of tissue, bleeding into the inner eye.	400 - 550 nm (Blue to Green) - Photochemical damage for exposure for more than several seconds. Visible exposure for thermal damage limited to one second by aversion response to bright light. Eye movement reduces hazard for longer durations
Far Infrared	Cornea and Lens	Thermal damage dominates. Denaturation (clouding) of the cornea and (at 1.4 - 1.9□m) lens. ***Short Pulses -*** Photoablation of corneal tissue with high powered pulses	Exposure for thermal damage normally limited to a few seconds by reaction to pain due to heating of the cornea. Long term infrared cataract (1.4 - 3 μm)

Table 1 - Summary of Principle Ocular Injuries for Ultraviolet, Visible and Infrared Radiation. [Courtesy of Pro Laser Consultants].

Laser radiation in the near infrared region (700nm - 1400nm) is not sensed by the eye either as light or as pain. The damage caused by this region of the electromagnetic spectrum can be very serious as the fraction of the power reaching the retina is high (see Figure 2) without the worker being aware of this.

Many of the most practical and hence prevalent diode and solid state lasers (e.g. Nd:YAG) lasers are in this wavelength range thus workers should be aware of their hazards.

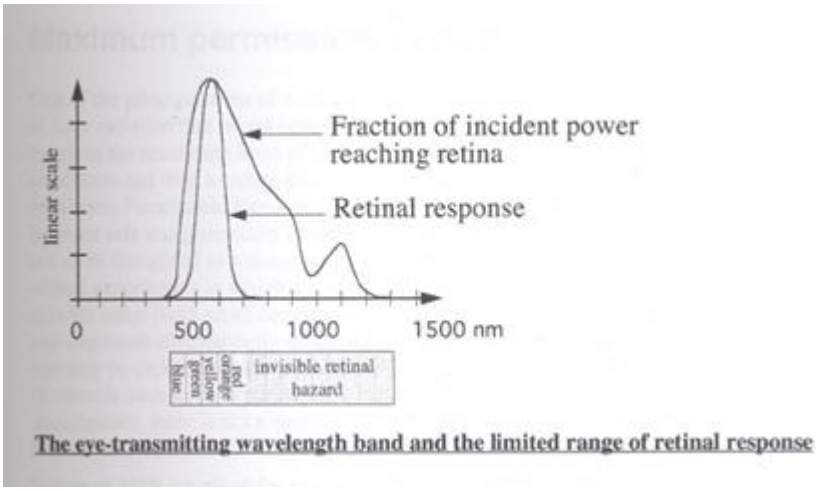


Figure 2: Illustration of high transmission to the retina of invisible radiation in the 700 - 1400 nm wavelength range. [Courtesy of Pro Laser Consultants.]

5.3 Laser Induced Injuries to the Skin

Laser radiation can have many effects on the skin depending on the wavelength, power and irradiance of the beam. Table 2 summarizes the effects of laser radiation on the skin.

Wavelength Range	Effects on the Skin	
Ultraviolet UV-C (180-280 nm) Ultraviolet UV-B (280-315 nm)	Erythema (Sunburn) Accelerated skin ageing Increased skin pigmentation	
Ultraviolet UV-A (315-400 nm)	Skin Darkening Photosensitive Reactions	Erythema (Sunburn)
Visible (400 - 780 nm)	Skin Darkening Photosensitive Reactions	Erythema (Sunburn)
Infrared IR-A (780 - 1400 nm) Infrared IR-B (1400 - 3000 nm) Infrared IR-C (3000 nm - 1 mm)		Erythema (Sunburn)

Table 2 - Summary of laser beam hazards to the skin.
[Courtesy of the Health Protection Agency]

5.4 Non-Coherent Artificial Optical Radiation Induced Injuries to Skin and Eyes

There are similar injuries caused by non-coherent light as with lasers. For example:

Wavelength		Eye	Skin
100 – 280 nm	UVC	Photokeratitis Photoconjunctivitis	Erythema Skin cancer
280 – 315 nm	UVB	Photokeratitis Photoconjunctivitis Cataracts	Erythema Elastosis (Photoageing) Skin cancer
315 – 400 nm	UVA	Photokeratitis Photoconjunctivitis Cataracts Photoretinal damage	Erythema Elastosis (Photoageing) Immediate pigment darkening Skin cancer
380 – 780 nm	Visible	Photoretinal damage (Blue light hazard) Retina burn	Burn
780 – 1400 nm	Infrared A	Cataracts Retinal burn	Burn
1400 – 3000 nm	Infrared B	Cataracts	Burn
3000 nm - 1 mm	Infrared C	Corneal Burn	Burn

Table 3 - Effects of Optical Radiation on Eyes and Skin.
[From: Non-binding guide to good practice for implementing Directive 2006/25/EC 'Artificial Optical Radiation' (European Community)]

6. Management of Artificial Optical Radiation Safety

The management reporting structure for safety of artificial optical radiation within the University is given in Appendix 1.

The use of hazardous AOR is managed through the University radiation Protection programme called RadProt (see URL: https://portal.st-andrews.ac.uk/radprot/open/)

This programme requires users to:

- Register the AOR sources they are using and where these sources are located;
- Register the person as an 'Approved User' (this requires that the user has received the appropriate training);
- Undertake a risk assessment for the project.

6.1 Laser Safety Training

All users (including staff, students, visiting research staff etc) of Class 1M, 2M, 3R, 3B and 4 lasers must complete the University Laser Safety Course on Moodle, including the test, to be found at URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=4404 .

The School/Unit Laser Safety Supervisor should be notified, who will also notify the University Laser Safety Adviser, of all visiting research workers who intend to use Class 1M, 2M, 3R, 3B or 4 lasers. The University Laser Safety Adviser will then decide on the level of training the visiting researcher should receive.

All previously trained users should undertake refresher training on a regular basis – preferably annually and no less than every 3 years.

6.2 Use of Non-Coherent Artificial Optical Radiation

Classification of non-coherent AOR sources can be found in Section 9 of this document. All Risk Group 3 AOR sources should be registered with the University Laser Safety Adviser.

All work with Risk Group 3 AOR sources, which pose a significant risk to workers, must have a suitable and appropriate risk assessment that includes the necessary control measures to minimise risks to workers and others in the immediate vicinity. Workers with such light sources should use RadProt or the risk assessment form as given in Appendix 6.

All Risk Group 3 AOR source users must receive appropriate training prior to work starting as these light sources pose a significant risk.

7. Definitions

There are many terms used in laser safety. This section will define some of these terms and note their significance.

Accessible Emission Limit (AEL) – Is the maximum accessible emission level permitted within a particular laser Class. How the power or energy contained within a laser beam at the point of exit from the laser equipment compares to the AEL for each laser Class will determine its classification.

Irradiance (E) - is the radiant power of a laser beam incident per unit area upon a surface and given in Watts per square metre (usually for Continuous Wave type lasers)

Laser Controlled/Designated area – an area containing a hazardous source where occupancy and activities within the area are subject to control and supervision to ensure safety.

Laser Hazard Area – The area around a source that is within the (extended) NOHD (see below).

Light Emitting Diodes (LEDs) - Incoherent sources of relatively narrow band optical radiation, which can still pose a significant risk of injury. LED safety is covered by BS EN 62471 – 'Photobiological safety of lamps and lamp systems', apart from their use in communications, which remains part of laser safety procedures.

Maximum Permissible Exposure (MPE) - This is the maximum level of energy that an organ can be exposed to without causing harm. It is usually about 10 times lower than the amount that causes harm in 50% of a population (ED50). The calculation of the MPE is complicated as it depends on the type of laser (continuous wave or pulsed laser), if pulsed, on the pulse frequency, the wavelength, time of exposure, organ being exposed (skin or eye usually). There are tables available to determine the MPE in different situations. The MPE determines acute effects and does not relate to chronic long term effects (e.g. cataracts). The MPE, also, does not take into account the severity of injury (e.g. may be just reddening of the skin or may carbonise skin). For example, a 1 mW laser beam through an aperture of 7mm (the size of a dilated eye pupil) has a MPE of 25 Wm^{-2}.

You should know the MPE for the lasers you work with. If you do not know this information, you should contact your School/Unit Laser Safety Supervisor.

Nominal Ocular Hazard Distance (NOHD) - This is the point on a divergent light beam where the irradiance or radiant exposure is equal to the MPE. If optically aided viewing is reasonably expected, the extended NOHD must be considered.

Radiant Exposure (H) - Is the power of a laser beam given in Joules per square metre (usually for pulsed lasers).

8. Classification of Lasers

Table 4 details the classification of lasers, the meaning of the classification and the warning label which should be attached to the equipment.

Class	Sub-Division	Meaning	Warning Label
Class 1 AEL<MPE	Intrinsic	Output in the range 180 nm – 1mm. Safe by virtue of the intrinsic low power of the laser, even with optical instruments	**Class 1 Laser Product**
	Engineering	Output in the range 180 nm – 1 mm. Embedded laser products safe by virtue of engineering controls e.g. total enclosure, guarding, scan failure mechanism	**Class 1 Laser Product**
Class 1M AEL<MPE only by virtue of the beam geometry	Collimated	Well collimated beam, output in range 302.5 - 4000 nm with large diameter that is safe for unaided viewing but potentially hazardous when a telescope or binoculars are used	**Laser Radiation Do not view directly with optical instruments (binoculars or telescopes) Class 1M Laser Product**
	High Divergence (e.g. LEDs)	Output in the 302.5 – 4000 nm. Safe for unaided viewing but potentially hazardous when an eye loupe or magnifier is used	**Laser Radiation Do not view directly with optical instruments (magnifiers) Class 1M Laser Product**
Class 2 Maximum Output less than 1 mW		Output in 400 - 700nm range. Safe for unintended exposure, even with the use of optical instruments by virtue of natural aversion response to bright light	**Laser Radiation Do not stare into beam Class 2 Laser Product**
Class 2M AEL < MPE only by virtue of the beam geometry	Collimated	Well collimated beam in the range 400 – 700 nm with large diameter that is safe for unaided viewing by virtue of the natural aversion response to bright light, but potentially hazardous when a telescope or binoculars are used.	**Laser Radiation Do not stare into the beam or view directly with optical instruments (binoculars or telescopes) Class 2M Laser Product**
	High Divergence (e.g. LEDs)	High divergence source with output in the range of 400 – 700 nm. Safe for unaided viewing by virtue of the natural aversion response to bright light but potentially hazardous when an eye loupe or magnifier is used.	**Laser Radiation Do not stare into the beam or view directly with optical instruments (magnifiers) Class 2M Laser Product**

Class	Sub-Division	Meaning	Warning Label
Class 3R Maximum output of laser equipment less than 5 mW	Visible - Near Infrared	Output in range 400 - 1400nm. Direct intrabeam viewing is potentially hazardous but the risk is lower than for Class 3B	**Laser Radiation Avoid Direct Eye Exposure Class 3R Laser Product**
	Other Wavelengths	Output in Ultraviolet (180 - 400nm) or Infrared (1400 nm - 1 mm). Direct intrabeam viewing is potentially hazardous but the risk is lower than Class 3B	**Laser Radiation Avoid Exposure to Beam Class 3R Laser Product**
Class 3B Typically output of laser equipment less than 500 mW		Medium Power Laser - Direct ocular exposure is hazardous even taking into account aversion responses but diffuse reflections are usually safe.	**Laser Radiation Avoid Exposure to the Beam Class 3B Laser Product**
Class 4 All higher power lasers		High Powered Laser - Direct exposure is hazardous to the eye and diffuse reflections may also be hazardous. Skin and potential fire hazards.	**Laser Radiation Avoid Eye or Skin Exposure to Direct or Scattered Radiation Class 4 Laser Product**

Table 4 - Classification of Lasers from BS TR 60825-14 (2004)

The classification of lasers is based on the British Standard BS EN 60825-1 and is derived from the Accessible Emission Limit (AEL) laser power output of a piece of equipment containing the laser, not the laser specifically. This means that equipment where the laser is totally enclosed and thus the AEL is effectively zero is deemed safe (and thus Class 1) even though a very high power laser is enclosed in the equipment. If, however, the enclosure is opened (e.g. by a service engineer) such that the beam is exposed, the equipment would now be classified by the power of the laser beam which is exposed. Thus any risk assessment of engineered Class 1 laser equipment must take into account if the containment will be accessed.

9. Classification of Non-Coherent Artificial Optical Radiation Sources

The British Standard BS EN 62471: 2008 details the classification of artificial optical radiation sources. There are 4 categories in this British Standard:

Category of Artificial Optical Radiation	Definition	Examples
Exempt Group	No direct optical radiation risks are reasonably foreseeable, even for continuous, unrestricted use. These sources **do not** pose any of the following photo-biological hazards: • an actinic ultraviolet hazard within 8 hours exposure • a near-UV hazard within 1 000 s • a retinal Blue-Light hazard within 10 000 s • a Retinal Thermal hazard within 10 s • an infrared radiation hazard for the eye within 1000 s • an infrared radiation hazard without a strong visual stimulus within 1000 s	Domestic and office lighting, computer monitors, equipment displays, indicator lamps, Class 1 laser
Group 1 - Low Risk	These products are safe for most applications, except for very prolonged exposures where direct ocular exposures may be expected. These sources **do not** pose any of following hazards due to normal behavioural limitations on exposure: • an actinic ultraviolet hazard within 10 000 s • a near-UV hazard within 300 s • a retinal Blue-Light hazard within 100 s • an infrared radiation hazard for the eye within 100 s • an infrared radiation hazard without a strong visual stimulus within 100 s	Battery torch
Group 2 - Moderate Risk	The sources that **do not** pose any of following hazards due to aversion response to very bright light sources, due to thermal discomfort or where lengthy exposures are unrealistic: • an actinic ultraviolet hazard within 1000 s • a near-UV hazard within 100 s • a retinal Blue-Light hazard within 0.25 s (aversion response) • a retinal Thermal hazard within 0.25 s (aversion response) • an infrared radiation hazard for the eye within 10 s • an infrared radiation hazard without a strong visual stimulus within 10 s	High pressure mercury floodlights, desktop projectors, vehicle headlights, UV insect traps, Class 1M, 2 or 2M lasers
Group 3 - High Risk	The sources that may pose a risk even for momentary or brief exposure within hazard distance. Safety control measures are essential.	UV Transilluminators, Welding & plasma cutting, Blue light and UV therapies, Class 3B or 4 lasers

Table 5 – Classification of Artificial Optical Radiation Sources from BS EN 62471; 2008

These examples are not exhaustive. If you are not sure what category a light source is, you should seek advice from the Director of Environmental, Health and Safety Services

10. Risk Assessments

It is a requirement of relevant legislation that a risk assessment be carried out for all work with a significant risk of injury and this will include work with lasers and high power artificial optical radiation sources.

Generic risk assessments can be done for low power Class 1, and Class 2 laser equipment and Risk Group 2 AOR sources. A specific written risk assessment should be produced for Class 1M, 2M, 3R, 3B and 4 laser equipment and Risk Group 3 AOR sources.

Where a risk assessment is being carried out, it is necessary to determine the Maximum Permissible Exposure Limit (MPE). This is the relevant irradiance (Wm^{-2}) or radiant exposure (Jm^{-2}) that is considered not to be hazardous. This is a complicated calculation depending on the mode of operation (e.g. pulsed or continuous wave), wavelength of radiation, time of exposure, area of the beam. For laser sources, this calculation is dependent on specific tables in BS TR 60825 - Part 14 (2004). The University Laser Safety Adviser can provide you with the necessary calculations. This should be the starting point for any risk assessment.

All risk assessments should be undertaken using the University's radiation management programme RadProt (see URL: https://portal.st-andrews.ac.uk/radprot/open/)

Risk assessments should be carried out for the procedure not just for work with individual laser/light source. Thus where work involves multiple lasers and with many non-optical hazards, one risk assessment form should be used. Assessments should preferably be entered directly into RadProt, however, the form which can be used to assess the risks of work with Class 1M, 2M, 3R, 3B and 4 lasers and Risk Group 3 AOR sources is given in Appendix 6.

NOTE: It is the duty of the Project Supervisor to undertake specific risk assessments where required and have them approved by the School/Unit Laser Safety Supervisor before the work starts. Such risk assessments should be reviewed by the Project Supervisor on an annual basis or when the work significantly changes.

10.1 Generic Risk Assessment for Class 1, and Class 2 Lasers

Work with these classes of lasers is considered to be less hazardous than other higher power lasers. The control measures which should be implemented for these lasers are:

Class 1 - No protective control measures are necessary under normal operation. (This may not be the case for engineered Class 1 laser equipment where the outer casing has been removed). In the case of embedded laser products containing a high power laser, follow the instructions given on the warning labels and supplied by the manufacturer.

Special written systems of work and other precautions may be needed for on-site servicing of embedded laser products.

Class 2 - Do not stare into the beam.

Do not direct the beam at other people or into areas where other people unconnected with the laser work might be present.

10.2 Work Activity with Class 1M, 2M, 3R, 3B and 4 Laser Equipment and Risk Group 3 Artificial Optical Radiation Sources

All work with Class 1M, 2M, 3R, 3B and 4 lasers and Risk Group 3 AOR sources requires a specific written risk assessment which should be undertaken on the University's radiation management programme RadProt (see URL: https://portal.st-andrews.ac.uk/radprot/open/)

The first part of the risk assessment is to describe the work activity, giving details of the project. This will give a background to the work and will allow an inspector to assess if suitable laser or AOR sources have been used for the work. This assessment should be done before the work starts by the Project Supervisor and a copy provided to the School/Unit Laser Safety Supervisor.

10.2.1 Hazards Associated with the Work

The hazards of the work activity should be clearly identified. This means identifying:

- The Class of laser and/or AOR source being used;
- Whether it is a pulsed or continuous wave source;
- The wavelength(s) of the radiation from the laser/AOR source;
- The power output of the source;
- Diameter of the beam or extended source;
- Whether the beam is collimated or divergent.

Working with lasers/AOR sources includes many other hazards which are not associated with the radiation. These include:

- Fire (Class 3B and 4 lasers and other AOR sources are powerful enough to initiate fires);
- Electricity supply (many AOR sources use high voltage/high current supplies, e.g. a 2 kW CO_2 laser will require a 100 Amp 3 phase power supply at 40 kW);
- High pressure water supply;
- Chemicals (many dye and excimer lasers use very hazardous substances);
- Mechanical equipment associated with the work;
- Manual handling operations (many gas lasers are large bulky items which are difficult to lift and carry);
- X-rays / Electromagnetic Interference (High voltage lasers, e.g. 5kV CO_2 lasers can generate significant quantities of X-ray ionising radiation)

10.2.2 Who is at Risk

It is very important to identify who is at risk. In general this will be the user but you should also consider other workers, for example:

- Other workers in the laboratory;
- Cleaning staff;
- Service engineers (who may open up Class 1 equipment exposing a laser beam greater than Class 1);
- The general public if an open air display is performed;
- Those susceptible to particular aspects of the work (e.g. pregnant women may be susceptible to some of the chemicals and manual handling operations).

10.2.3 The Risk of the Work Activity

The risk of an operation is the probability that a hazard will cause harm. Thus, in the assessment, consideration should be given to identify work procedures which increase the probability that a particular hazard will cause harm. The assessment should take into account non-optical-radiation hazards as well as assessing the AOR risks.

Examples of factors which may increase the risk of an operation include:

- The use of non-visible wavelengths of light, thus workers will not see the hazard;
- Highly complex optical systems which mean that it is difficult to identify where the optical radiation is and where it is going;
- Stray radiation where there is no proper containment in place;
- The use of periscopes thus moving a laser beam vertically towards the eyes of workers;
- Use of open systems (thus the potential for stray optical radiation to be generated and injure a worker);
- Alignment of laser beams by eye increases the risk of an eye injury;
- Poor housekeeping (items which may fall into the path of the optical radiation and cause stray radiation to be generated);
- Wearing of reflective items by workers, e.g. jewellery, which may cause stray radiation;
- The use of high pressure water systems in close proximity to high voltage/current electrical supplies;
- Working with hazardous substances associated with the optical equipment without any fume extraction system;
- No training in manual handling operations for those having to move large, awkward and possibly heavy equipment;
- Using lasers which generate X-rays or electromagnetic interference without appropriate shielding in place.

10.2.4 The control measures which should be implemented

The purpose of a risk assessment is to identify and implement the necessary control measures to eliminate or minimise the risks to workers and to others which may be affected by the work. This section is the most important part of the risk assessment process.

There is a hierarchy of control measures which should be implemented:

- **Eliminate the risks** - Where it is reasonably practicable, the risks involved should be eliminated.

- **Substitute the risks** - If it is not possible to eliminate the risks, then can you substitute it with a less hazardous procedure. Examples of substitution include:- can you use an AOR source which is less hazardous; can you substitute any hazardous substance with a less hazardous substance etc.

- **Engineering Controls** - If it is not practicable to eliminate or substitute the hazard, then you should, where reasonably practicable, put in place engineering control measures such that the optical radiation is contained within the necessary work area and cannot escape and injure others. Examples of engineering controls which should be considered include:
  - Fully enclosing the equipment such that the optical radiation is never fully exposed (e.g. making a piece of laser equipment Class 1 even though a more powerful laser is enclosed in the equipment);

- Put in place containment barriers which are capable of handling the power of the source (it is no use using a bit of paper as a beam stop for a very high power Class 4 laser as this will be set alight by the laser);
- Enclosing all periscopes to ensure no stray laser beams are generated vertically towards the workers eyes;
- Where reasonably practicable, enclosing laser beam paths in tubing of an appropriate material;
- Putting appropriate shielding around an optical table to avoid stray optical radiation escaping from the optical table;
- The use of web-cameras or other devices for the alignment of laser beams or observation of an experiment;
- The use of interlocked access doors to rooms or equipment boxes containing Class 3B or Class 4 lasers or Risk Group 3 AOR sources, which either switch off the power to the equipment or put a shutter in the path of the optical radiation at its source. This will stop personnel walking into a room or removing covers being exposed to harmful optical radiation;
- Putting in place appropriate Residual Current Circuit Breakers (RCCBs) to avoid the potential for electric shock to workers;
- Ensuring water supplies are well managed when in close proximity to electrical supplies;
- Where reasonably practicable, all work with hazardous substances is carried out in a Local Exhaust Ventilation system (e.g. a fume cupboard);
- Other engineering controls which may be appropriate for the optical equipment being used.
- Where engineering controls are provided, they must be maintained and serviced at appropriate frequencies to ensure they are working correctly.

- **Procedural Controls** - Where elimination, substitution and engineering controls are not reasonably practicable, then appropriate procedural controls should be implemented. This is where specific procedures are introduced to minimise the risk of work with high power AOR, including lasers. For example, by introducing a written system of work to inform workers what procedures they must follow when working with a particular piece of laser equipment.

- **Personal Protective Equipment (PPE)** - Only as a very last resort should PPE be considered as a control measure to minimise the risks of equipment generating high power AOR, including laser systems. This is because the equipment is not totally effective and will only protect the worker (other systems protect the user and other workers in the laboratory).

Eye protection can be afforded by wearing suitable laser safety eyewear, but its effectiveness is limited as protection is dependent on the wavelength and the power of the source.

Where none of the above control measures can be implemented, then suitable safety eyewear must be supplied and worn by workers. It is vital that workers are aware of the limitations of such eyewear and which type of glasses/goggles should be worn.

The School/Unit should ensure that safety eyewear is well maintained. Guidance on the usage, maintenance and storage of PPE is given in the University publication entitled 'The Selection, Use and Maintenance of Personal Protective Equipment (PPE)' which can be viewed at the following website: http://www.st-andrews.ac.uk/services/safety/webpages/ppe/ppe-policy.html

The protection provided by laser safety eyewear is shown by specific markings on the glasses/goggles - For Example: DR 630-720 L5 CE95 ZZ S

- D protect against continuous wave
- R protect against giant pulsed waves
- 630-720 Protect against wavelength range of 630 - 720 nm
- L5 Attenuates laser radiation by 10^5
- CE95 European test marking and date tested
- ZZ Testing authority
- S Mechanical strength test (optional marking)

All safety eyewear protection should be checked by the worker before use for damage and suitability for the work being undertaken. Where such PPE is damaged, it should be taken out of service immediately, reported to the Project Supervisor and replaced as soon as reasonably practicable.

10.3 Monitoring and Review

Risk assessments should be reviewed on a regular basis or when there is a significant change to a project by the Project Supervisor.

10.4 Risk Assessments of Outdoor Laser Demonstrations

There are strict guidelines for such demonstrations (See HSE Guidance document: http://www.hse.gov.uk/pubns/priced/hsg95.pdf). If a group wishes to undertake such work, they should contact the University Laser Safety Adviser for guidance and approval of the activity prior to the activity being undertaken.

11. Contractors working on Laser Systems

Prior to the work starting, the contractor should liaise with the School/Unit Laser Safety Supervisor over the health and safety arrangements that will be required.

All contractors involved in high power AOR source maintenance must produce a System of Work, which should include a risk assessment, prior to the start of the work. The System of Work will identify all the necessary arrangements which need to be implemented to protect the contractor and workers at this University. This is especially important where Class 1 laser equipment is opened exposing a laser beam of a rating higher than Class 1.

12. Laser and Artificial Optical Radiation Hazard Areas

Rooms where work with Class 3B and Class 4 laser equipment or Risk Group 3 AOR sources should be undertaken in a controlled area. Such areas should comply with the following requirements:

- For laser work, the room access door should have a sign on it identifying it as a 'Laser Designated Area', with an appropriate laser warning sign. The sign should also have the name and contact number for the School Laser Safety Supervisor and person responsible for the work.
- For other AOR work, the controlled area should be identified using appropriate 'Optical Radiation' warning signs.

- To restrict access to Laser Designated Areas, the doors to Laser Designated Areas should be interlocked to the lasers such that opening the door switches off the power to the laser or puts a shutter in to the beam path close to its source.
- The optical radiation should not be able to leave the room e.g. all windows should be 'blacked out'.
- The provision, where reasonably practicable, of a high level of general illumination within the area so that the pupil of the eye remains as small as possible.
- The walls, ceilings, flooring and fittings should be covered with a matt paint to reduce potential specular reflections of the optical radiation.
- The removal of all unnecessary equipment from the area.
- The elimination or minimisation of reflective surfaces from the area e.g. glass fronted cabinets.
- The provision of adequate ventilation (this will depend on the type of hazardous substances being used for the work activity).
- All optical equipment being used with the sources should be mounted and fixed on an optical table to reduce accidental movement and hence unexpected direct or reflected optical radiation.
- The provision of adequate fire-fighting equipment.
- The provision of seating within the laser area must not give rise to an increased risk as a result of reduced eye level.
- The fitting of appropriate electrical supplies and relevant control equipment designed to:
    - Prevent accidental illumination of the equipment;
    - Provide an indication of the state of readiness of equipment such as associated capacitor banks;
    - Enable personnel to stand in a safe place;
    - Incorporate all relevant electrical safety features;
    - Enable the equipment to be shut down;
    - Enable the equipment to be isolated and made safe from outside the Controlled Area in the event of a fire or emergency.

13. Health Surveillance

In general terms and from experience, there is no need for pre-employment or regular health surveillance of workers unless they are exposed to a serious risk of injury. Regulation 6 of the Control of Artificial Optical Radiation Regulations 2010 requires that if a risk assessments identifies there is a serious risk to eyesight or skin by the optical radiation then appropriate health surveillance by an Occupational Physician/Adviser should be carried out. Advice on such health surveillance can be obtained from the Occupational Health Adviser.

A medical examination should be made available to a worker if it is suspected or known that they have been exposed to artificial optical radiation in excess of the legal exposure limit or if a worker is found to have an identifiable disease or adverse health effects, which is considered to be a result of exposure to artificial optical radiation.

It is important that the person carrying out the medical examination is familiar with the potential adverse health effects from the specific sources of workplace exposure to artificial optical radiation. If this is the case then the following actions should be triggered:

- The worker should be informed of the results;
- The worker should receive information and advice regarding follow-up health surveillance;
- The employer should be informed, respecting any medical confidentiality;
- The employer should review the risk assessment;

- The employer should review the existing control measures (which may involve seeking specialist advice);
- The employer should arrange any necessary continued health surveillance.

14. Emergency Actions

In the event that a person has been exposed to a laser beam, or other artificial optical radiation believed to be in excess of the maximum permitted exposure, directly to the eye, the person should be taken directly to an Ophthalmic Consultant at the Ophthalmic Department, Ninewells Hospital, Dundee. The person (or person accompanying the injured person) should take details of the source which may have caused the injury (e.g. wavelength of the beam, power output etc) and information on the possible length of time the person may have been exposed to the beam.

After the person has been to Ninewells Hospital, a University Accident Report Form should be completed and signed by the School Safety Co-ordinator. A copy of the accident report form must be sent to the Director of EHSS as some incidents may require the University to report the incident to the Health and Safety Executive (this report is sent by the University Safety Adviser).

A copy of these instructions should be posted in all Controlled Areas (see Appendix 7).

15. Inspections

The School / Unit should inspect all facilities where laser or other hazardous AOR equipment is being used on an annual basis. Where the systems do not meet relevant standards, remedial action should be implemented as a matter of urgency.

Safety audits and safety tours of areas where hazardous AOR work is performed will be carried out by representatives of the Radiations Hazards Management Group at regular intervals.

16. Undergraduate Experiments and Lecture Demonstrations with Lasers

Where reasonably practicable, the least hazardous sources should be used for undergraduate practical work and lecture demonstrations (i.e. Class 1, 1M, 2 and 2M lasers or Risk Group 1 and 2 AOR sources).If higher power sources are used then they should be embedded within systems where the accessible emission is below the maximum permitted exposure.

Where such work requires the use of higher power lasers, then an appropriate risk assessment should be performed and the necessary control measures implemented to eliminate or minimise the risks.

When such assessment is being performed, as well as the standard risks of the work, consideration must be given to the inexperience of undergraduates and that teaching laboratories may not have been designed as Laser Designated Areas (thus there may still be reflective surfaces present).

It is suggested, therefore, that the following special conditions should be observed for undergraduate work or demonstrations with Class 3R, 3B or 4 lasers:

- The safety of the experiment or demonstration should be risk assessed by the lecturer and the School Laser Safety Supervisor;
- A written system of work should be produced for this work;

- A copy of the risk assessment and system of work should be displayed in a position which can be clearly seen by the persons carrying out the work;
- A copy of the instructions should be given to each student who must be informed of the risks of exposure to laser beams if the instructions are not followed;
- The School Laser Safety Supervisor should visit the experiment at reasonable intervals;
- Lasers must not be accessible to students at any time other than when they are being used in approved experimental work.

17. Laser Pointer Safety

Laser pointers are now used regularly in lectures and other teaching activities. It has been noted that some of the new pointers, which are readily available in the UK and include red and green devices, are more powerful than the older models and pose a serious risk of eye injury to anyone exposed to the beam. This apparent irregularity of devices being available that may be hazardous arises in part due to American (ANSI) standards being more relaxed than British/European Standards (BS EN). Laser pointers used in areas under the control of the University of St. Andrews must comply with the following University policy based on BS EN standards:

17.1 Device Requirements

- Laser Pointers must not exceed Class 2 (1 mW visible output power);
- Laser Pointers must be purchased from reputable manufacturers and suppliers;
- Laser Pointers may only be modified under certain circumstances (e.g. output power reduction) and only with the approval of the University Laser Safety Adviser.
- The School/Unit should keep a record of all University Laser Pointers so that regular inspections of these pointers can be undertaken.

17.2 Conditions of Use

- Ambient lighting should be kept as high as practicable - blackout conditions should be avoided whenever practicable;
- Laser Pointers must not be directed towards eyes;
- Prior to use, checks should be made that there are no reflective surfaces that could foreseeably redirect the laser beam towards eyes (user and audience);
- Schools / Units are required to take steps to ensure that all relevant persons are made aware of this guidance, including visitors to the University of St. Andrews.

17.3 Further Recommendations

- The use of green or red (500 – 630 nm) waveband laser pointers is recommended. These wavelengths afford greater visibility per unit power;
- If visiting another establishment and intending to use a laser pointer, you should first check the local regulations.

18. Confocal Microscope Equipment

18.1 Confocal Microscopes

Confocal microscopy provides a means of combining high-resolution imaging with depth selectivity, so allowing the production of high resolution 3D images or image slices of a sample. Illumination of the sample is provided by a laser source or sources, which may be in the UV,

visible or infrared spectral ranges. The laser may be of up to Class 4 and hence extremely hazardous to both eye and skin tissue, however, when embedded within the confocal microscope equipment often allows a lower classification of Class 1(M), 2(M) or 3R to be applied. Although the beam is often accessible between the objective lens and sample table, this distance is short and the beam highly convergent as it approaches the sample and divergent beyond. Exposure may also arise from diffuse scatter from the sample. Under normal operating conditions the equipment will usually present only a low risk of injury.

It is anticipated that there may at times be need for maintenance to be carried out on confocal microscope equipment, requiring opening of the laser enclosure and possible exposure to hazardous Class 3B or Class 4 optical radiation from the embedded laser sources.

The rules and guidance in this Section are provided to implement at a practical level the University's 'Policy and Guidance on Work with Lasers and High Power Artificial Optical Radiation' in regard to the safe operation and maintenance of confocal microscopes.

18.2 Registration and Classification of Confocal Microscope Equipment

Each confocal microscope brought into the University and containing a Class 3R, 3B or 4 laser source must be registered with the University via the RadProt database.

For each confocal microscope containing a Class 3R, 3B or 4 laser source, a classification exercise must be carried out by the person responsible, with advice where required from the School/Unit Laser Safety Supervisor. Two classifications are required to be carried out based on the worst case scenario of laser power/wavelength, these being under (i) normal operating and (ii) maintenance conditions. These classifications should take into account manufacturer supplied information. The outcome of this classification exercise will determine the safety measures required to be taken.

18.3 Working Environment

18.3.1 General Considerations

In accordance with normal University safety requirements arising from Health and Safety at Work legislation, the responsible person must ensure that all work is risk assessed and standard operation procedures put in-place, prior to work commencing. The assessment and mitigation of identified hazards should take into consideration both normal operation and maintenance of the equipment. Where Class 3R, 3B or 4 laser radiation is accessible either under normal or maintenance operations, the risk assessment should be recorded using the RadProt database, noting both the optical radiation and other non-optical hazards associated with use of the equipment.

18.3.2 Normal Operation

Where under normal operating conditions the equipment is classified as Class 1(M), 2(M) or 3R, there is no requirement for the equipment to be located within a Laser Designated Area. Special arrangements are, however, likely to be required for maintenance operations (see Section 18.3.3).

Where under normal operating conditions the equipment is classified as Class 3B or Class 4 laser equipment, the equipment must be located in a Laser Designated Area and standard precautions appropriate to the working environment and training of users for high power optical radiation work must be followed. These are described elsewhere in the University's

'Policy and Guidance on Work with Lasers and High Powered Artificial Optical Radiation' (this document), which forms part of the necessary training for use of such equipment.

18.3.3 Maintenance Operations

From time-to-time it is expected that maintenance operations, for example alignment and reconfiguration of lasers, may require to be carried out; which will involve access to the laser enclosure and possible exposure to Class 3B or Class 4 laser radiation.

Where Class 3B or Class 4 laser radiation is accessible during maintenance operations and the equipment is not located within a laser designated area, special precautions must be taken to avoid accidental exposure of workers to hazardous optical radiation. This is likely to require the setting-up of a controlled area and include:

- Securing the room in which the equipment is located to prevent unauthorised access;
- Exclusion of all workers not fully trained in open beam laser work;
- Placement of No Entry and Knock & Wait signs on the door;
- Screening of any windows including transparent door panels.

A Scheme of Work, incorporating a risk assessment, must be prepared prior to maintenance work commencing and access to the equipment generally restricted to qualified service engineers only while the laser enclosure is open and the laser operating.

18.4 User Training

18.4.1 Low Risk Equipment (Class 1(M), 2(M) or 3R) - Normal Operation

Equipment classified as Class 1(M), 2(M) or 3R should pose no risk of exposure to hazardous optical radiation to the user. Consequently, it is not necessary for users of such equipment to undertake the full laser safety training course. Specific equipment training must be provided by the School/Unit and must highlight that low risk confocal microscopes do contain powerful and hazardous laser sources and consequently standard operating procedures must be adhered to; with particular reference made to the hazards associated with accessing the laser enclosure. A record of users having received training is required to be kept by the School/Unit.

18.4.2 Low Risk Equipment (Class 1(M), 2(M) or 3R) - Maintenance Operations

Where Class 1M, 2M, 3R, 3B or Class 4 laser radiation is accessible during maintenance operations only qualified service engineers or users who have undertaken the full University laser safety training course may be present within the controlled area while the laser enclosure is open and the laser operating. It is expected that the University Laser Safety Adviser will be notified of planned maintenance to low risk equipment containing higher risk sources and provided with a copy of the planned Scheme of Work.

Where only Class 1 or Class 2 laser radiation is accessible under maintenance operations, work may be carried out by all authorised users of the equipment, while observing standard laser and other safety precautions – DO NOT STARE INTO THE BEAM.

18.4.3 High Risk Equipment (Class 3B and Class 4)

All users of high risk confocal microscope equipment must undertake the University's full Moodle based laser safety training course (URL - https://moody.st-andrews.ac.uk/moodle/course/view.php?id=4404). On completion of this course the user

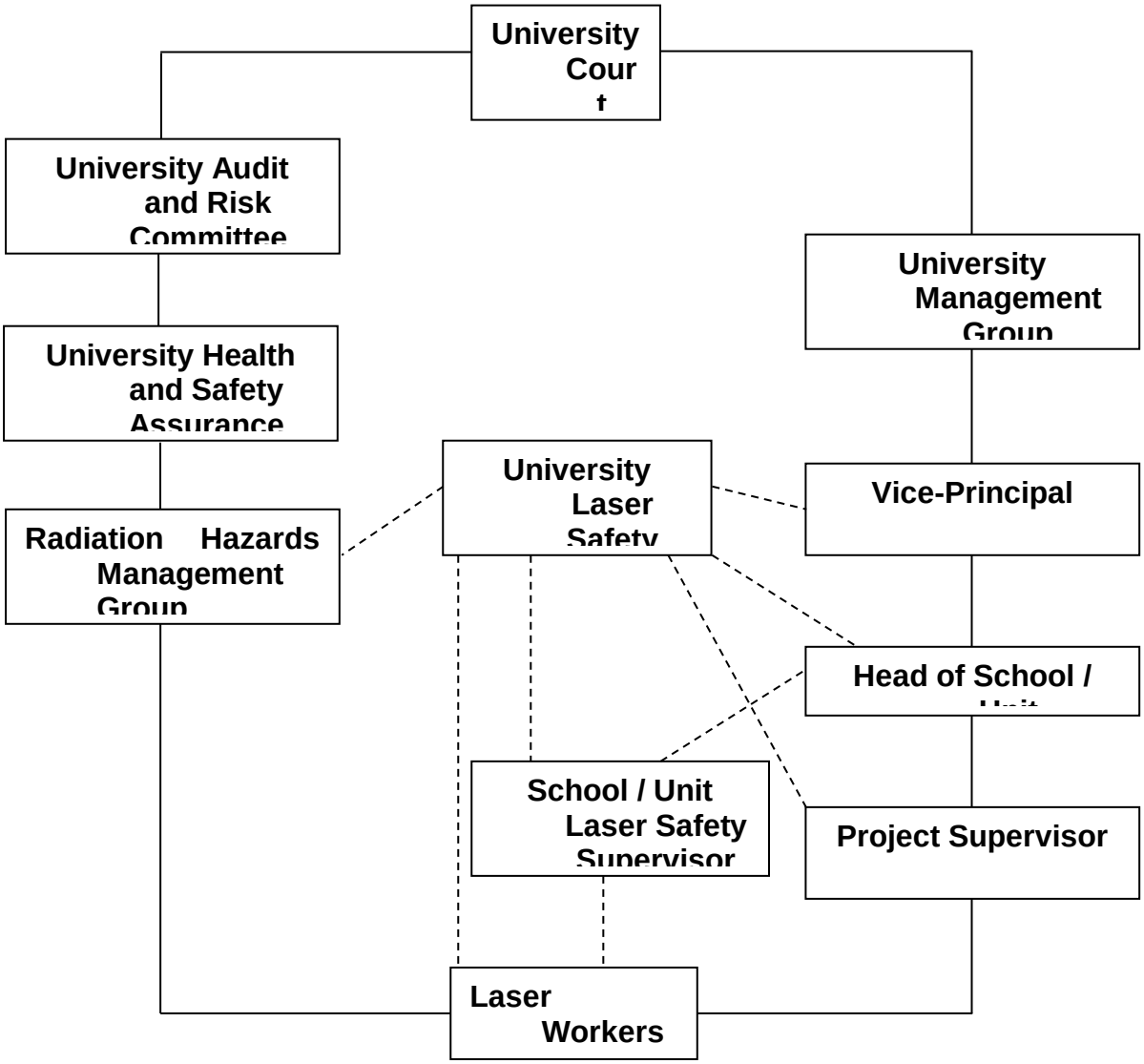
will be registered by the University Laser Safety Adviser as an authorised laser worker with Class 3B and Class 4 laser equipment.

Specific equipment training must also be provided by the School/Unit. A record of users having received training is required to be kept by the School/Unit.

18.5 Laser Safety Monitoring of Confocal Microscopes

Where the equipment is classified as Class 3B or Class 4 under normal operation, the safe use of the equipment will be monitored as for any other similarly classified laser source within the University. This will generally mean the equipment and its operating environment will be inspected annually, or sooner if significant changes are made.

Appendix 1 University Management of Artificial Optical Radiation Safety



Appendix 2 Radiations Hazards Management Group

Members

- University Radiation Protection Adviser(s) (URPA)
- University Laser Safety Adviser
- University Safety Adviser
- DRPS - Centre for Biomolecular Sciences
- DRPS - Bute Medical Building, School of Biology
- DRPS - Gatty Marine Laboratory, School of Biology
- DRPS - Sir Harold Mitchell Building, School of Biology
- DRPS - School of Chemistry (Radioactive sources only)
- DRPS - School of Chemistry (X-ray equipment only)
- DRPS - School of Earth and Environmental Sciences
- DRPS - School of Physics and Astronomy
- DRPS - School of Psychology
- Convenor - URPA
- Secretary – URPA

Appendix 3 Remit of the University Laser Safety Adviser

The University Laser Safety Adviser has the following duties:

1. Advise the University Radiations Hazards Management Group of the University Health and Safety Assurance Group on matters relating to laser safety;
2. Provide laser safety advise to Senior University Management, Heads of Schools/Units, The University Radiation Protection Service, School/Unit Laser Safety Supervisors and laser workers;
3. Provide information, instruction and training in laser safety to University laser workers;
4. Investigate all suspected laser accidents and near misses and ensuring that appropriate medical advice has been sought after such incidents;
5. Carry out laser safety audits on behalf of the Radiation Hazards Management Group at appropriate intervals;
6. Ensure that Schools/Units register all lasers, except for Class 1 and Class 2;
7. Ensure that all users of lasers, except Class 1 and Class 2, are registered with the School/Unit and have received appropriate training.

Appendix 4 Hazardous Artificial Optical Radiation User Registration Form

URPS/LW(2018)

University of St Andrews
Registration of Persons as Users of Hazardous Artificial Optical Radiation Sources

Registration ID (Office Use):

Full Name: _____

School/Unit: _____ Supervisor's Name: _____

Personal Details

Date of Birth: _____ Nationality: _____

Employment/Student Status: _____ University email: _____

Training and Other Details

Laser Safety Training Received (e.g. Online (Moodle) Course, LIMITS CD, Training Seminar...). Please include place and date of training. In addition to any other training, all laser workers must read the University's Policy and Guidance on Work with Lasers and High Power Artificial Optical Radiation:
https://www.st-andrews.ac.uk/ehss/healthandsafety/radiation/

Training Details:

Other Details:

I have read and understood the University Policy and Guidance on Work with Lasers and High Power Artificial Optical Radiation

Signed (Worker): _____ Date: _____

Notes:
1. All Laser Workers using Lasers of Class 1M, 2M, 3R, 3B and 4 or Users of other harmful artificial optical radiation (Risk Group 3) must be trained and registered with the School/Unit Laser Safety Supervisor before starting work.
2. After completion return this form to the School/Unit Lasers Safety Supervisor before starting work.

Worker Informed of Emergency Procedures: Date: _____

Received (LSO): _____ Date: _____

Appendix 5 Registration of New Hazardous Artificial Optical Radiation Source Form

URPS/LE(2018)

University of St Andrews

Registration of Hazardous Artificial Optical Radiation Sources

School: _____ Location (Bldg/Room No.): _____

Principal Investigator: _____ Internal Extension: _____

Equipment Identification

Manufacturer: _____

Model: _____

Serial Number: _____

Equipment Details

Laser Class/AOR Group: Select

Gain/Source Type: _____

Wavelength:	_____	_____	_____	_____
Mode[1]:	_____	_____	_____	_____
Max. Average Power (W):	_____	_____	_____	_____
Pulse Duration (s):	_____	_____	_____	_____
Repetition Rate (s^{-1}):	_____	_____	_____	_____
Source/Beam Size (mm):	_____	_____	_____	_____

Other Details:

Notes:

1. For equipment delivering a complex pulse train, please describe the pattern as fully as possible in the Other Details space provided, e.g. burst duration, frequency of burst, intra-burst repetition rate....
2. A Risk Assessment must be completed prior to commencing work with the source. This should be completed on RadProt or contact the School/Unit Laser Safety Supervisor for further guidance.
3. All Laser Workers using Lasers of Class 1M, 2M, 3R, 3B and 4 or Users of other harmful artificial optical radiation (Risk Group 3) must be trained and registered with the School/Unit Laser safety Supervisor before starting work.
4. Where required, appropriate safety eyewear must be provided to workers and visitors.
5. A written system of work will be required prior to the start of any work carried out by service engineers on-site.

Work carried out using this source will be done so in accordance with the University Policy and Guidance on Work with Lasers and High Power Artificial Optical Radiation

Signed (PI): _____ Date: _____

Received (LSO): _____ Date: _____

Appendix 6 Hazardous Artificial Optical Radiation Risk Assessment Form

URPS/LRA(2018)

UNIVERSITY OF ST ANDREWS

RISK ASSESSMENT FOR WORK INVOLVING HAZARDOUS ARTIFICIAL OPTICAL RADIATION (INCL. LASERS)

Registration ID (Office Use):

School/Unit: _____ Location (Bldg/Room No.): _____

Principal Investigator: _____ Internal Extension: _____

Title of Activity: _____

Notes

1. All work with lasers and other sources of harmful artificial optical radiation must comply with the University Policy and Guidance on Work with Lasers and High Power Artificial Optical Radiation.
2. Generic risk assessments have been performed for Class 1 and 2 laser equipment and are available in the above University publication.
3. All workers using Class 1M, 2M, 3R, 3B and 4 lasers and Risk Group 3 AOR must be trained and registered with the School/Unit Laser Safety Supervisor before work commences.
4. All workers engaged in the work described herein must be signatories to the risk assessment and comply with any guidance provided.
5. A separate written scheme of work will be required prior to the start of any work carried out by service engineers on-site.
6. Preferably the Risk Assessment should be completed directly on the University RadProt management software and this form only used if access is not available.

Equipment Identification and Details

Equipment Registration Number:	_____	_____	_____	_____
Laser Class/AOR Group:	_____	_____	_____	_____
Gain/Source Type:	_____	_____	_____	_____
Wavelength:	_____	_____	_____	_____
Mode[1]:	_____	_____	_____	_____
Max. Average Power (W):	_____	_____	_____	_____
Pulse Duration (s):	_____	_____	_____	_____
Repetition Rate (s^{-1}):	_____	_____	_____	_____
Source/Beam Size (mm):	_____	_____	_____	_____

Other Details:

Description of Work/Procedure (brief outline of type of work being undertaken)

Who is at Risk (Identify all groups of persons at risk from this work. This may include: laser workers, visiting researchers, maintenance personnel, cleaning staff, students, other persons…)

Type of Risk? (Identify the type of risk associated with the use of the sources in this activity)

Eye Injury Skin Injury Fire (due to optical radiation)

Any Other Optical Radiation Related Hazards

Actions Associated with the Activity Resulting in Risk from Optical Radiation (Identify the origin of risks associated with the use of the source(s) in this work. This may include: worker inexperience, open beam paths, use of periscopes, lone work, unauthorised access to controlled area…. Include with each risk identified an estimate of the Risk Rating on a scale of 1-5 of the probability and the severity of injury; 5- probable, 5 – very severe)

Control Measures used to Eliminate or Minimise Identified Risks (Detail the measure taken to mitigate each of the identified risks. This may include; training, engineering controls – door interlocks, enclosures, beam stops, etc., written systems of work and, as a last resort, personal protective equipment - eyewear)

Type of Risk (non-optical radiation hazards)? (Identify other type(s) of risk associated with this activity – check all that apply)

Fire	Electric Shock	Slits/Trips/Falls	Manual Handling
Chemical	Biological	Ionising Radiation	Cryogenics
Explosion	Compressed Gasses	Pressure Systems	Hot Objects
Magnetic Fields	Confined Spaces	Lighting	Moving Parts/Machinery

Any Other Non-Optical Radiation Related Hazards

Control Measures used to Eliminate or Minimise Non-Optical Radiation Risks (Detail the measure taken to mitigate each of the identified non-optical radiation related risks. This may include; training, engineering controls RCCB's, PAT testing written procedures....)

Name of Worker	Signature	Laser/AOR Safety Training Received		
		Date of Training	Place of Training	Details of Training (seminar, on-line course, etc.)

Work carried out using this laser/AOR source will be done so in accordance with the University Policy and Guidance on Work with Lasers and High Power Artificial Optical Radiation.

Signed (PI): _____ Date: _____

Received (LSO): _____ Date: _____

Appendix 7 Emergency Procedures (Contact University Laser Safety Adviser for copies of this notice)

EMERGENCY PROCEDURES

ACCIDENTS INVOLVING OPTICAL RADIATION

IF AN EYE INJURY IS SUSPECTED, EMERGENCY EXAMINATIONS WILL BE CARRIED OUT AT NINEWELLS HOSPITAL, DUNDEE.

CONTACT: OPTHALMIC IMAGING (Area 6A Outpatients, Level 7) - 09:00 – 17:00

OPTHALMIC WARD (Ward 25) - 17:00 – 09:00

TELEPHONE: Ninewells Hospital main switchboard 01382 660111 (it is not necessary to phone prior to attending)

EXAMINATIONS SHOULD BE CARRIED OUT AS SOON AS POSSIBLE AND WITHIN A PERIOD NOT EXCEEDING 24 HOURS.

IF PRIVATE TRANSPORT IS NOT AVAILABLE (DO NOT DRIVE YOURSELF) A TAXI SERVICE SHOULD BE USED.

IN THE EVENT OF AN ACCIDENT OR NEAR MISS THE FOLLOWING PERSONS SHOULD BE NOTIFIED AS SOON AS REASONABLY PRACTICABLE – DO NOT DELAY SEEKING MEDICAL ASSISTANCE WHERE REQUIRED

Head of School : ……

Ext.: …… email: ……

Unit Laser Safety Supervisor : ……

Ext.: …… email: ……

Unit Safety Manager : ……

Ext.: …… email: ……

Note: Accidents and near misses must be reported to the Director of Environmental, Health and Safety Services as soon as reasonably practicable.

Version number	Purpose / changes	Document status	Author of changes, role and school / unit	Date
V1.0	Revision	Draft	Paul Szawlowski	21/06/2019