Health & Safety Directorate

Artificial Optical Radiation
Queen Mary University of London
Health and Safety Policy

(Ref: QMHSD_HS_PCY014)

Contents

1.0 Executive Summary

1.1 This Health and Safety Policy establishes the framework for the risk assessment, the risk controls and the health & safety measures to be adopted and implemented for the use of Artificial Optical Radiation by Queen Mary University of London (Queen Mary) staff and students; and also, for others who may be affected by Queen Mary activities. The objective of the Policy is to reduce, so far as is reasonably practicable, the risk of harm, injury or damage, enable legal compliance and promote best practice.

1.2 The Policy defines the types of Optical Radiation and considers their use in the context of Queen Mary's activities; identifies the roles and responsibilities for Heads/Managers of Schools / Institutes / Directorates, and for staff, students and others who may be affected, and notes the key legal and compliance requirements.

1.3 Guidance on practical measures (including training, supervision and competencies) for Queen Mary L and resources for the risk assessment of the use of Devices that produce Artificial Optical Radiation are provided or linked. The Policy has been issued following consultation with Heads/Managers of Schools/Institutes/Directorates, the Queen Mary Health & Safety Advisory Group and staff/student representatives.

2.0 Introduction

2.1 Sources of artificial optical radiation play a vital role in the University, with hugely diverse functions, from task lighting to communications to material analysis.

2.2 For the most part the radiation they emit poses no risk, however this is not always the case, and it is vital that this is recognised, and adequate controls are put in place.

2.3 Harm may be caused by direct exposure to radiation leading to acute or chronic health effects, but also through the action of radiation on the physical environment, for example evolution of toxic fume.

2.4 This policy informs the structures and processes that the University uses to

- identify and characterise risk.
- minimise risk to tolerable levels.
- take remedial action when required.
- educate and inform staff, students, and others regarding their responsibilities.
- interact with regulators.

3.0 Purpose

3.1 To reduce, as far as reasonably practicable, the likelihood of damage to persons or property through activities involving the use of artificial optical radiation.

3.2 To promote best practice and a sound understanding of applicable legislation and derived guidance relating to the use of artificial optical legislation.

3.3 To ensure full statutory compliance with applicable legislation.

4.0 Scope

4.1 This Policy applies to all Queen Mary staff, students and others (e.g. contractors, visitors) who may be affected by Queen Mary activities when on Queen Mary premises as well as through activities that are undertaken off site such as fieldwork for example.

5.0 Legislation

5.1 The Artificial Optical Radiation at Work Regulations 2010 (AOR10) require you to protect the eyes and skin of your workers from exposure to hazardous sources of artificial optical radiation (AOR). AOR includes light emitted from all artificial sources in all its forms such as ultraviolet, infrared and laser beams, but excludes sunlight.

5.2 In addition the general requirements of the Health and Safety at Work Act 1974 and the Management of Health and Safety at Work Regulations 1999 require that a risk assessment of the work activity is undertaken, that significant findings are recorded, and that appropriate control measures are implemented. The Provision and Use of Work Equipment Regulations 1998, Control of Substances Hazardous to Health Regulations 2002, Dangerous Substances and Explosive Atmospheres Regulations 2002, Manual Handling Operations Regulations 1992, Genetically Modified Organisms (Contained Use) 2014 may also be applicable depending upon the procedures being undertaken and identified by risk assessment. The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 are also applicable in the event of an incident where the person has sustained a reportable injury.

6.0 Terms and Definitions

6.1 Non-Coherent and Coherent Radiation

6.1.1 Non-coherent light sources

exhibit the following properties:

- Polychromatic: A range of wavelengths are produced and therefore potential colours.
- High intensity at source but reduces quickly with distance.
- Highly divergent: spreads out over an area with distance.
- Emit light with frequent and random changes of phase between the photons.

Conventional light sources are all non-coherent, in the majority of applications there is no additional requirements placed upon the University and Section 7: Non-Coherent Radiation provides further information.

The table below details the common wavelengths and their applications.

Wavelength Region	Used for	Adventitiously produced during
UVC (100-280nm)	Germicidal sterilisation Fluorescence (laboratory) Photolithography	Ink curing Some area and task lighting Some projection lamps Arc welding
UVB (280-315nm)	Sunbeds Phototherapy Fluorescence (laboratory) Photolithography	Germicidal lamps Ink curing Some area and task lighting Projection lamps Arc welding
UVA (315-380nm)	Sunbeds Phototherapy Fluorescence (laboratory) Photolithography Ink curing Insect traps	Germicidal lamps Area and task lighting Projection lamps Arc welding
Visible (380nm- 750nm)	Area and task lighting Indicator lamps Traffic signals Hair and thread vein removal Ink curing Photolithography	Sunbeds Some heating/drying applications Welding

	Photography Photocopying Projection TV and PC screens	
IRA (750nm- 1µm)	Surveillance illumination Heating Drying Hair and thread vein removal Communications	Some area and task lighting Welding
IRB (1 µm-10µm)	Heating Drying Communications	Some area and task lighting Welding
IRC (10 µm to 100 µm)	Heating Drying	Some area and task lighting Welding

6.1.2 Coherent radiation

is light which has the following properties:

- All photons have the same frequency, polarisation, direction, speed and phase.
- Monochromatic – one wavelength (colour)
- Very intense and of high power per unit area
- Has low divergence – the light does not spread out from the beam.

The most common form of coherent light at Queen Mary are Lasers and these are capable of causing significant harm if uncontrolled. Section 6.4 Coherent Radiation: provides further information on the University requirements for using these devices.

The tables below provide examples of common Lasers in use at Queen Mary and their applications.

Type	Laser	Principal wavelength	Output
Gas	Helium Neon (HeNe)	632.8 nm	CW up to 100 mW
	Helium Cadmium (HeCd)	422 nm	CW up to 100 mW
	Argon Ion (Ar)	488 nm, 514 nm plus blue lines	CW up to 20 W
	Carbon dioxide (CO_2)	10600 nm	Pulsed or CW up to 50 kW
	Nitrogen (N)	337.1 nm	Pulsed > 40 uJ
	Xenon chloride (XeCl) Krypton fluoride (KrF) Xenon Fluoride (XeF) Argon fluoride (ArF)	308 nm 248 nm 350 nm 193 nm	Pulsed up to 1 J
Solid state	Ruby	694.3 nm	Pulsed up to 40 J
	Neodymium: YAG (Nd:YAG)	1064 nm and 1319 nm 532 nm and 266 nm	Pulsed or CW up to TW, 100 W average CW
Fibre	Ytterbium	1080 – 1120 nm	CW up to kW
Thin disk	Ytterbium: YAG (Yb:YAG)	1030 nm	CW up to 8000 W
Semi-conductor	Various materials e.g. GaN GaAlAs InGaAsP	400 – 450 nm 600 – 900 nm 1100 – 1600 nm	CW (some pulsed) up to 30 W
Liquid (Dye)	Dye – over 100 different laser dyes	300 – 1800 nm 1100 – 1600 nm	Pulsed up to 2.5 J CW up to 5 W

Category	Application
Materials processing	Cutting, welding, laser marking, drilling, photolithography, rapid manufacturing
Optical measurement	Distance measurement, surveying, laser velocimetry, laser vibrometers, electronic speckle pattern interferometry, optical fibre hydrophones, high speed imaging, particle sizing
Medical	Ophthalmology, refractive surgery, photodynamic therapy, dermatology, laser scalpel, vascular surgery, dentistry, medical diagnostics
Communications	Fibre, free-space, satellite
Optical storage	Compact disc/DVD, laser printer
Spectroscopy	Substance identification
Holography	Entertainment, information storage
Entertainment	Laser shows, laser pointers

6.2 Health Effects

Optical radiation is absorbed in the outer layers of the body and, therefore, its biological effects are mostly confined to the skin and eyes but systemic effects may also occur. Different wavelengths cause different effects depending on which part of the skin or eye absorbs the radiation, and the type of interaction involved: photochemical effects dominate in the ultraviolet region, and thermal effects in the infrared. Laser radiation can produce additional effects characterised by very rapid absorption of energy by tissue, and is a particular hazard for the eyes where the lens can focus the beam.

The biological effects can be broadly divided into acute (rapidly occurring) and chronic (occurring as a result of prolonged and repeated exposures over a long time). It is generally the case that acute effects will only occur if the exposure exceeds a threshold level, which will usually vary from person to person. Most exposure limits are based on studies of thresholds for acute effects, and derived from statistical consideration of these thresholds. Therefore, exceeding an exposure limit will not necessarily result in an adverse health effect. The risk of an adverse health effect will increase as exposure levels increase above the exposure limit. The majority of effects described below will occur, in the healthy adult working population, at levels substantially above the limits set in the Directive. However, persons who are abnormally photosensitive may suffer adverse effects at levels below the exposure limits.

Chronic effects often do not have a threshold below which they will not occur. As such, the risk of these effects occurring cannot be reduced to zero. However, by reducing exposure and observance of the exposure limits should reduce risks from exposure to artificial sources of optical radiation to levels below those which society has accepted with respect to exposures to naturally occurring optical radiation.

The risks associated with chronic exposure to UV (especially the lower wavelengths) are an enhanced risk of developing skin cancers. The formal guidance from the United Kingdom Health Security Agency (UKHSA) is that exposure to UV radiation should be minimised as far as practicable.

6.3 Non-coherent Radiation sources

The majority of light sources are safe, such as those described below, if you only have these sources, or similar, you don’t need to do anything further.

When making this decision, it is also worth considering the following points to satisfy yourself that all workers are protected:

- If you have workers whose health is at particular risk, (e.g. those with pre-existing medical conditions made worse by light).
- If workers use any chemicals, (e.g. skin creams) which could react with light to make any health effects worse.
- If you have workers who are exposed to multiple sources of light at the same time.
- If exposure to bright light could present unrelated risks, (e.g. temporary blindness could lead to mistakes being made in hazardous tasks).

6.3.1 Safe light sources

All forms of ceiling-mounted lighting used in offices etc that have diffusers over bulbs or lamps.

All forms of task lighting including desk lamps and tungsten-halogen lamps fitted with appropriate glass filters to remove unwanted ultraviolet light.

- Photocopiers.
- Computer or similar display equipment, including personal digital assistants (PDAs).
- Light emitting diode (LED) remote control devices.
- Photographic flashlamps – when used singly.
- Gas-fired overhead heaters.
- Vehicle indicator, brake, reversing and fog lamps.
- Any exempt or Risk Group 1 lamp or lamp system (including LEDs), as defined in British Standard BS EN 62471: 2008

There are also some sources of light that, if used inappropriately, e.g. placed extremely close to the eyes or skin, have the potential to cause harm but which are perfectly safe under normal conditions of use. Examples include:

- Ceiling-mounted fluorescent lighting without diffusers over bulbs or lamps.
- High-pressure mercury floodlighting.
- Desktop projectors.
- Vehicle headlights.
- Non-laser medical applications such as: operating theatre and task lighting; diagnostic lighting such as foetal/neonatal trans-illuminators and X-ray light/ viewing boxes.
- UV insect traps.
- Art and entertainment applications such as illumination by spotlights, effect lights and flashlamps (provided that any ultraviolet emissions have been filtered out).
- Multiple photographic flashlamps, for example in a studio.
- Any Risk Group 2 lamp or lamp system (including LEDs), as defined in British Standard BS EN 62471: 2008.

The above list is not exhaustive. If you have sources that are not listed but you know have not caused harm previously, and you have no reason to suspect they present a risk in the way they are used, you can assume no special control measures are needed.

6.3.2 Hazardous Sources

For other devices containing hazardous sources of light that present a 'reasonably foreseeable' risk of harming the eyes and skin of workers a formal risk assessment must be undertaken to ensure adequate control measures are in place.

Examples of activities that may require further controls are:

- Metal working – welding (both arc and oxy-fuel) and plasma cutting.
- Pharmaceutical and research – UV fluorescence and sterilisation systems.
- Hot industries – furnaces.
- Printing – UV curing of inks.
- Motor vehicle repairs – UV curing of paints and welding.
- Any Risk Group 3 lamp or lamp system (including LEDs), as defined in British Standard BS EN 62471: 2008, for example search lights, professional projections systems.

The above list is not exhaustive. If you are still unsure whether the sources, you have are hazardous you could use information provided by suppliers. They have a duty under Section 6 of the Health and Safety at Work Act 1974 to design, manufacture and supply articles for use at work that are safe, so far as is reasonably practicable, in all reasonably foreseeable circumstances of use. If unsure of the harm a source poses or the applicable controls, please contact the University Non-ionising radiation protection officer.

If a source presents a risk of harm, they should provide information and instruction on how this risk should be managed as well as making sure the articles they supply for use at work are appropriately CE-marked.

6.4 Coherent Radiation (Lasers)

Failure to manage lasers safely can lead to serious irreversible consequences with the damage occurring in a very short period of time. Of particular concern is the potential injury that can be caused to the eyes by the focusing of the radiation onto the retina, or serious burns to unprotected skin.

Not all Lasers require full control as outlined below and this is determined by their classification (Section 8.2) and intended use.

Class 1 and 2 lasers are considered to be safe for use providing no direct beam viewing or magnification is involved at any point during operation – for example laser printers, bar code scanners and low power laser pointers.

For Lasers of Class 3R, 3B, 4 and Class 1 by design equipment that has embedded 3B or 4 Lasers where access to the open beam is required for servicing and maintenance, the duties outlined below must be followed.

6.4.1 Hazard Classification

Lasers are grouped according to ability to do harm, the higher the number the greater the harm. The current laser classes are: 1, 1M, 2, 2M, 3R, 3B and 4.

The classification scheme is defined in the standard BS EN 60825-1 and is based on the amount of radiation "accessible" to the user –the Accessible Emission Limit (AEL). This value defines the maximum power of each class of laser under normal operation, including any safety systems. Non normal operations may well be during servicing, where the enclosure of a laser is removed or when setting up a laser.

A laser or laser product is regarded as “safe” if the maximum permissible exposure (MPE) at the characteristic wavelength of the laser is not exceeded. NB the hazard depends on the wavelength of the emitted energy as well as the energy density.

MPE levels are given in PD 60825 Part 14. Exposure Levels are normally quoted in units of W m-2 for CW lasers, and J m-2 for pulsed lasers. Users of open beam lasers must avoid exposures which may be greater than the MPE, which may require calculation of the maximum possible duration of exposure as part of the risk assessment.

It is imperative that all laser products are classified according to UK standards. Where this is not the case, it is the legal responsibility of the purchaser to classify them. Given the complex and highly technical nature of this process it should only be undertaken after a consultation with the relevant Head of Department and the University Non-ionising radiation protection officer. Equipment which does not meet the relevant standards must never be used.

Class 1 (AEL<0.3mW)

Class 1 lasers are products where the irradiance (measured in watts per metre square) of the accessible laser beam (the accessible emission) does not exceed the Maximum Permissible Exposure (MPE) value. Therefore, for Class 1 laser products the output power is below the level at which it is believed eye damage will occur. Exposure to the beam of a Class 1 laser will not result in eye injury and may therefore be considered safe. However, some Class 1 laser products may contain laser systems of a higher class but there are adequate engineering control measures to ensure that access to the beam is not reasonably likely. Examples of such products include laser printers and compact disc players. Anyone who dismantles a Class 1 laser product that contains a higher-class laser system is potentially at risk of exposure to a hazardous laser beam. A laser that is inherently safe and cannot exceed the MPE under any circumstances is exempt from the classification system.

Note that a Class 1 laser product may contain a Class 4 laser system but be safe by engineering design. The control measures may include restricting access to the laser beam by enclosures and interlocked panels. In some applications, the beam may only present a risk of injury over small distances. It is sometimes necessary to restrict access to the area where the beam is cutting or welding material so as to avoid exposure to moving parts and material ejected from the work site.

In some instances, products with higher powered embedded lasers may require access to the beam during servicing. This need should be understood at the point of acquisition such that the designated location is able to support this process with additional management arrangements in place- i.e. able to prevent unauthorised access, prevent beams leaving the space via unobstructed windows.

Class 1M (AEL<0.3mW)

Class 1M lasers are products which produce either a highly divergent beam or a large diameter beam. Therefore, only a small part of the whole laser beam can enter the eye. However, these laser products can be harmful to the eye if the beam is viewed using magnifying optical instruments. Some of the lasers used for fibre-optic communication systems are Class 1M laser products.

Class 2 (AEL<1mW)

Class 2 lasers are limited to a maximum output power of 1 mW and the beam must have a wavelength between 400 and 700 nm. A person receiving an eye exposure from a Class 2 laser beam, either accidentally or as a result of someone else's deliberate action (misuse) will be protected from injury by their own natural aversion response. This is a natural involuntary response that causes the individual to blink and avert their head thereby terminating the eye exposure. Repeated, deliberate exposure to the laser beam may not be safe. Some laser pointers and barcode scanners are Class 2 laser products.

Class 2M (AEL<1mW)

Class 2M lasers are products which produce either a highly divergent beam or a large diameter beam within the wavelength range 400 to 700 nm. Therefore, only a small part of the whole laser beam can enter the eye, and this is limited to 1 mW, similar to a Class 2 laser product. However, these products can be harmful to the eye if the beam is viewed using magnifying optical instruments or for long periods of time.

Class 3R (AEL<5mW)

Class 3R lasers are higher powered devices than Class 1 and Class 2 and may have a maximum output power of 5 mW or five times the Accessible Emission Limit (AEL) for a Class 1 product. The laser beams from these products exceed the maximum permissible exposure for accidental viewing and can potentially cause eye injuries, but the actual risk of injury following a short, accidental exposure, is still small.

Class 3B (AEL<0.5W)

Class 3B lasers may have an output power of up to 500 mW. Class 3B lasers may have sufficient power to cause an eye injury, both from the direct beam and from reflections. The higher the output power of the device the greater the risk of injury. Class 3B lasers are therefore considered hazardous to the eye. However, the extent and severity of any eye injury arising from an exposure to the laser beam of a Class 3B laser will depend upon several factors including the radiant power entering the eye and the duration of the exposure. Examples of Class 3B products include lasers used for physiotherapy treatments and many research lasers.

Class 4 (AEL>0.5W)

Class 4 lasers have an output power greater than 500 mW. There is no upper restriction on output power. Class 4 lasers are capable of causing injury to both the eye and skin and will also present a fire hazard if sufficiently high output powers are used. Lasers used for many laser displays, laser surgery and cutting metals may be Class 4 products. Many Class 4 laser products are safe during normal use but may not have all of the protection measures required for a Class 1 product. An example would be an enclosure with an open roof; it is possible that someone could get a ladder and climb over the enclosure to get access to the laser beam.

6.5 Non-Beam Hazards

Other hazards that may be present in the laser laboratory must be included in the risk assessment. Some of these may be directly connected with the operation of the laser itself, for example, the provision of high voltage power supplies operating at potentials of several kV, where others may be only indirectly connected to the laser operation – for example, the presence of cables to ancillary equipment trailing across the floor.

Some of the equipment associated with high power lasers is very heavy, and crushing accidents have been reported when units were inadequately secured. The hazards associated with pumps and motors must be given adequate consideration e.g. guarding, venting of exhausts, etc. The use of cryogenic coolants may cause cold burns or asphyxiation due to liquid nitrogen boiling off in an unventilated space or fire risk if flowing hydrogen is used etc.

Adventitious x-radiation may be generated by high voltage rectifiers. Equipment operating at more than 5 kV is covered by the Ionising Radiations Regulations. Where appropriate, precautions must be taken against exposure to UV radiation.

Some types of lasers rely on the input of energy (for example, from a Xenon flash tube or from another laser) into a chemical dye solution. The chemicals used are often toxic and some may be carcinogenic. The chemical hazards may well outweigh the laser hazards, and the Control of Substances Hazardous to Health (COSHH) Regulations will apply. In addition, if the chemical dyes are dissolved in flammable solvents, the Dangerous Substances and Explosive Atmospheres (DSEAR) Regulations may well apply. In all cases a COSHH assessment must be included for all chemicals used in association with lasers. Any control measures identified by the COSHH assessment must be adopted, including the adoption of less hazardous materials/techniques. Many of the substances used in dye lasers are potential carcinogens, and exposure must be prevented or minimised.

Where the laser is used to burn or ablate a material or substance an assessment of the fume from the laser action must be assessed, an example of an unforeseen outcome is the release of Cyanide from polyurethane based materials.

Use of UV sources may generate ozone which presents a health hazard. Adequate ventilation should be in place and if necessary, monitoring of zone levels should take place.

7.0 Roles and Responsibilities

7.1 Non- coherent radiation sources

7.1.1 Head of Department/School/Institute

Heads of Department are responsible for ensuring that Line Managers / PI's within their department undertake a risk assessment for all devices where a Hazardous Source has been identified, in accordance with this policy.

7.1.2 Line Manager / PI

Are responsible for undertaking a suitable risk assessment and implementing appropriate controls before the device is operated.

Are responsible for ensuring device users are trained in accordance with this policy.

Are responsible for monitoring the use of the device to ensure they are operated in accordance with the risk assessment.

Are responsible for reviewing the risk assessment, local rules and operating arrangements on an annual basis.

7.1.3 Users

Must make themselves aware of the requirements of the risk assessment and seek clarification if these are not fully understood.

Must attend training as identified by their supervisor.

Must not undertake procedures that they have not been suitably trained or authorised to undertake or undertake without appropriate supervision.

Must use and maintain any personal protective equipment that has been identified during a risk assessment.

7.2 Coherent radiation sources

7.2.1 Head of Department/School/Institute

Heads of Department are responsible for ensuring that all lasers within their department are operated in accordance with this policy.

Heads of Department, where appropriate, are responsible for identifying a suitable person to act as Departmental Laser Supervisor. The appointment should be confirmed in writing and documented within the departments Statement of Health and Safety Organisation.

7.2.2 University Laser Safety Officer (ULSO)

The ULSO is appointed by the Director of the Health and Safety Directorate.

The ULSO is responsible for providing advice to Departments, Schools and Institutes on the implementation of this policy in relation to relevant legislation and British Standards.

The ULSO is responsible for maintaining a University inventory of relevant lasers.

The ULSO is responsible for providing advice to departments on appropriate risk assessments and the required level of control.

The ULSO is responsible for coordinating University wide training on laser for School laser Safety Officers and Laser Users.

7.2.3 School Laser Safety Officer (SLSO)

Must be appointed, by the Head of Department, School or Institute whenever Class 3 or above lasers are operated. This includes any embedded laser in a lower class product that might be exposed during routine servicing or maintenance.

Is responsible for maintaining a record of all relevant lasers in the department.

Is responsible for providing advice to research supervisors on the process of laser risk assessment and the appropriate level of control.

Is responsible for ensuring all lasers are appropriately labelled.

Is responsible for providing guidance or, if appropriate, direct training on the use of lasers.

Is responsible for providing advice on the correct selection of personal protective equipment.

Is responsible for carrying out an annual inspection of all lasers and must report the findings through the Departmental Health and Safety Committee to the Head of Department, with a copy to the Health and Safety Directorate.

Should seek assistance from the Health and Safety Directorate and the University Laser Safety Officer for clarification on laser safety.

7.2.4 Line Manager / PI

Line Managers / PI's are responsible for ensuring their lasers are operated in accordance with this policy.

Are responsible for registering all lasers with the Departmental Laser Supervisor.

Are responsible for ensuring lasers are correctly classified.

Are responsible for undertaking a suitable risk assessment and implementing appropriate controls before the system is operated.

Are responsible for authorising any new laser user.

Are responsible for ensuring laser users are trained in accordance with this policy.

Are responsible for maintaining a training record for each laser user, which identifies the processes they are deemed competent to undertake.

Are responsible for monitoring the use of lasers to ensure they are operated in accordance with the local rules/Scheme of Work.

Are responsible for reviewing the risk assessment, local rules and operating arrangements on an annual basis.

7.2.5 Laser users

Must make themselves aware of the requirements of the local rules and seek clarification if these are not fully understood.

Must comply with the requirements of the local rules or immediately highlight problems to their supervisors when these cannot be met.

Must attend training as identified by their supervisor.

Must not undertake procedures that they have not been suitably trained or authorised to undertake or undertake without appropriate supervision.

Must use and maintain any personal protective equipment that has been identified during a risk assessment.

8.0 Policy / Operational Arrangements

8.1 Laser Registration

All lasers (with the exception of Class 1 and 2 lasers) must be registered with the Health & Safety Directorate database before they are used.

In some instances, equipment is classified as Class 1 in normal use but there will be some limited circumstances where access to the beam is required during maintenance- if that is the case the equipment must be registered according to the classification of embedded laser.

On registration a University Laser Number [ULN] will be issued: the supervisor of the laser must attach a self-adhesive label to the instrument to clearly show this number.

Any change of location for the laser must be notified to the SLSO and HSD so that the database can be kept up to date.

8.2 Risk assessment

Before the appropriate controls can be selected and implemented, hazardous optical radiation sources (referred to as sources for brevity) must be identified and evaluated together with non-beam hazards that may be present. The sources capability of injuring personnel and the environment and the way in which the source or sources to be used needs consideration.

A risk assessment must be carried out to establish the significant risks and whether suitable and effective controls exist. Risk assessments should consider AOR 10 Regulation 3 Assessment of the risk of adverse health effects to the eyes or skin created by exposure to artificial optical radiation at the workplace and in particular Regulation 3(5) deals with what the assessment must include consideration of:

- Level, wavelength and duration of exposure
- The exposure limit values
- The effects of exposure on employees or groups of employees whose health is at particular risk from exposure
- Any possible effects on the health and safety of employees resulting from interactions between artificial optical radiation and photosensitising chemicals
- Any indirect effects of exposure such as temporary blinding, explosion or fire
- The availability of alternative equipment designed to reduce levels of exposure
- Appropriate information obtained from health surveillance, including where possible published information
- Multiple sources of exposure
- Any Class 3B or Class 4 laser or any other optical source that is capable of presenting the same level of hazard
- Information provided by manufacturers in accordance with product directives.

8.3 Controls

Control measures should follow the hierarchy of control and aim to reduce risk by:

- Elimination or substitution
- Engineering
- Administrative
- PPE

8.3.1 Elimination or substitution

Consideration should be made as to whether you need to use the proposed source, is there an alternative of lower risk that would achieve the same objective. E.g.- Can the proposed laser be operated at a lower power output, can wavelength with less risk of chronic health effects be employed.

8.3.2 Engineering

Access prevention

Enclosing a source system appropriately should eliminate or minimise the risk. The use of barriers and enclosures is an effective way of reducing exposure, by default hazardous sources should be enclosed; open beam work needs to become the exception and there must be very good robust justification not to enclose a Class 4 or Class 3B laser beam. In some cases, Class 3B lasers will often need at least partial enclosure (justification for open beams must be written into the accompanying risk assessment). Enclosure materials must be suitable for the intended purpose; a risk assessment may identify a reasonably foreseeable risk of the beam striking the guard and, in this case, it will need to be able to withstand the exposure. The likelihood of burn-through must be considered, and monitoring may be necessary, for example, using temperature sensors. Commonly used materials are metals such as black anodised aluminium and plastic that is opaque to the laser wavelength.

The enclosure must be securely fixed in place, preferably without supporting any optical components, and it must be capable of containing the beam for as long as is required.

Enclosures may also be needed to contain the process, for example, where fumes and particulates are emitted. Guards or barriers may be used to prevent damage from moving machinery.

Viewing windows

Filter material may be used in viewing windows. The type of material will depend upon wavelength, power and likely exposure duration.

Remote Viewing Aids

It is often very useful to visualise the laser beam during normal operation or alignment. The safest and easiest way to do this is to view remotely using a CCD camera, available for ultraviolet, visible and infrared. You may be able to use a simple web cam, which is cheap and easy to set up.

Interlocks

Access Panel Interlocks. An access panel interlock is used to reduce the source power to the appropriate ELV when the panel is opened, or keep the panel locked while the laser is turned on. E.g.- a UV curing oven shuts off when opened.

Laboratory Door Interlocks. For Class 3B and 4 laser installations, if other engineering control measures are in place, which reduce exposure to the ELV or below, door interlocks will be superfluous. It is far better to protect everyone by means of engineering controls. In some circumstances, it may be more appropriate to have access control by means of swipe card access with an override (e.g. break glass) for emergencies. If an interlock is used, there should be a manual reset for the laser to resume operation, not simply restarting when door is closed (the laser restarting unexpectedly could be hazardous).

Requirements for override switches. An access panel override switch is usually left on during servicing, this must then automatically turn off when the panel is replaced. It must not be possible to leave a door override switch continuously on, if there is a need for the switch to be controlled from the outside (for example during long experiments), it must be used only by authorised persons using a key or code. There must be a visible or audible warning to clearly indicate operation and ensure that any visible warning can be viewed through protective eyewear.

Methods of Interlocking. The power supply may be interlocked so that the source is switched off when the interlock is tripped. Alternatively, in situations where interrupting the power supply may cause damage to the source, or if the source requires time to re-stabilise, an interlocked beam shutter may be used. The shutter should be gravity fed. All Class 3B and 4 lasers and optical sources capable of exposure over the ELV should have an interlock connector which can be connected to an interlock control system. The principle of keeping exposure as low as practicable applies- if it is possible to interlock the source then it should be, unless risk assessment can justify the alternative.

8.3.3 Administrative

Scheme of Work/Local Rules

These must be written for all work with Class 3B/4 lasers. They must contain as much detail as possible about the protocol of the experiment itself, including:

- descriptions of the activity
- details of the laser(s) being used
- authorized users (See Section 8.5)
- Name and contact details of the PI and SLSO
- experimental set-up (with engineering controls in place to prevent an accident)
- alignment procedures
- day-to-day safety checks
- maintenance arrangements including details of any permit to work system
- adding new equipment to the set-up
- Emergency procedures and incident reporting systems

Signed hard copies of the Scheme of Work must be kept in the lab relating to that laser(s) and must be accompanied by the Laser risk assessment.

Signage

All laser areas should be clearly identified by appropriate signage at all access points into the area:

- Laser warning starburst
- Denote the class of laser in operation in the area
- Contact details for the PI/SLSO

8.3.4 PPE

Where required eyewear, should be provided to protect the user from accidental exposure. If other control measure have been implemented, then eyewear may still be required and provided if there is a foreseeable risk of exposure above the ELV.

Eyewear should be appropriate for the power and wavelength of the laser used. It should be CE or UKCA marked and conform to EN207 (Safety eyewear) or EN208 (Alignment eyewear).

Where multiple lasers are in use, each set of eyewear should be clearly marked to prevent users from selecting incorrect PPE.

Eyewear should be stored in a protective case or rack to prevent damage. If damage is suspected the eyewear should be removed from use and replaced.

Clothing that protects the skin may be required for working with devices in the ultraviolet region. There may also be a requirement for clothing to be flame retardant or heat resistant if the device poses a fire hazard.

Gloves may be required for preparing chemicals, cleaning or other activities as identified through a risk assessment.

In all instances PPE must meet the individual needs of the user.

8.4 New Facilities

If practicable, the laser laboratory should have a high level of illumination that will minimise pupil size.

To enhance illumination and reduce specular reflections, walls, ceiling and fittings should be painted with light coloured matt paint.

Reflecting surfaces, such as glass, should be avoided.

Windows should be kept to a minimum, and may need to be covered with blinds, these blinds should be non-reflective and adequately fire-resisting, where higher-powered lasers are used.

Ventilation needs to be considered: - if cryogens are used - if toxic fumes need to be extracted (in which case the extraction should be located as close to the source as possible) - if it is determined that heat gain from equipment requires cooling - if there are fumes or dust that require extraction.

Consider the facilities and arrangements for the handling of toxic chemicals that are associated with some dye lasers.

Positioning of electrical supplies, and laser switch and control gear should:

- enable the laser to be made safe in an emergency from outside the laser area
- enable personnel to stand in a safe place during work
- prevent accidental firing of lasers
- give an indication as to whether the laser is powered up
- enable a person standing next to the laser to switch it off easily.

8.5 Training

Initial training will be a basic instruction in laser hazards, risks and their control. Class 3R, Class 3B and Class 4 laser workers should attend training before commencing any laser work and should also be familiar with the schemes of work/protocols provided. A record of attendance should be made.

The HSD course “HS022 Laser safety awareness” should be used to provide this basic level of background information. It may also be useful for persons with management responsibility for products with embedded lasers. School Laser Safety Officers have the ability to enrol students onto this course and monitor attendance.

Training in the use of individual lasers is the responsibility of the Research Supervisor/Principal Investigator and a record of this training must also be made.

Appropriate refresher training should also be provided to ensure that people are kept up to date with the latest legal and standards' requirements.

Laser workers should be sufficiently competent in the operation and use of the equipment and should understand the general nature of laser radiation.

Training should include:

- the associated health hazards, the tissues of the body at risk, and the severity of harm which can result.
- The different laser classes and the meaning of the warning labels appropriate to the classes.
- The proper use of hazard control procedures and where appropriate the need for personal protective equipment.
- The need for any necessary additional precautions when undertaking non-routine activities; and
- Queen Mary procedures and policy governing laser use, including emergency action and accident reporting procedures.

8.6 Emergency Planning

Some common unsafe practices that are causes of preventable laser accidents are:

- Lack of pre-planning and failure to follow safety protocols.
- Misaligned optics and upwardly directed beams – pay particular attention to periscopes, and reflections from windows and beam splitters/combiners.
- Available eye protection not used particularly during alignment procedures.
- Wearing the wrong eyewear.
- Bypassing of door interlocks and laser housing interlocks.
- Insertion of reflective materials into beam paths.
- Lack of protection from non-beam hazards.
- Improper methods of handling high voltage.
- Operating unfamiliar equipment.

All accidents, incidents and 'near-misses' must be reported on MySafety and also reported to the SLSO as soon as possible after the event. Any eye injury caused by a laser is reportable to the Health and Safety Executive under the Reporting of Injuries, Diseases, and Dangerous Occurrences Regulations 2013. Once the area has been made safe, the state of the room must remain undisturbed, in case a follow-up inspection is required.

A Laser Incident Grab Sheet should be available for all laser setups, and easily accessible in case of emergency.

If an incident involves a known, or suspected, eye injury an emergency medical examination must be carried out as soon possible.

Moorfield's Eye Hospital

162 City Road

London EC1V 2PD

Tel: 020 7253 3411

8.7 Use of Lasers Off-Site

Laser users/ supervisors should also be aware of the need to ensure the safety of third parties e.g. employees or students of a host employer or institution.

No (registered) laser may be taken away from the University e.g. for a lecture, a demonstration, or for research purposes, without the permission the SLS.

The operator concerned will be held directly responsible for ensuring that all safety requirements are met and must, if requested, obey the instructions of the host institution's LSO and Departmental Laser Supervisor.

Full information provided to the SLSO should include any contracted arrangements, conditions applicable, locations and intended use.

8.8 Laser Displays

Most lasers that are used in entertainment and public exhibition work emit beams that are powerful enough to cause significant eye injury. In cases where the radiant beam powers exceed 0.5 Watt, exposed people may receive skin burns.

Guidance on laser displays and shows can be found in PD IEC/TR 60825-3 Ed 2.0 and the published guidance from the Professional Lighting and Sound Association (PLASA).

Organisers of events at which lasers are used for display should:

- Ensure that a general risk assessment has been carried out to identify relevant hazards and appropriate control measures are in place, in advance of any display.
- Ensure that requirements of the PLASA guide are complied with and that any statutory notifications are made.
- Comply with any arrangements and conditions as laid out in this policy.

Where the relevant precautions above are not implemented for a particular class of laser, a justification needs to be made in the appropriate documentation/protocol for the display.

It should be noted that deliberate scanning of an audience with laser beams should not be permitted unless a rigorous assessment of the likely exposure, and any foreseeable fault conditions, show that the applicable ELV will not be exceeded. When the radiant power of a visible laser beam exceeds about 10 mW, the MPE for the eye will generally be exceeded even when the beam is scanned.

8.9 Monitoring

The compliance by Queen Mary Departments / Directorates / Schools and Institutes with this Policy are monitored by the regime of health and safety inspections, peer review inspections and audits and by reports to the Department / Directorate / School / Institute Health and Safety Groups and the Faculty / Professional Services H&S Management Groups. Summary reports to the Queen Mary H&S Advisory Group and Queen Mary Senior Executive (QMSE) to evaluate ongoing Queen Mary compliance and efficiency of control measures are produced by HSD.

9.0 Further Information

- Artificial Optical Radiation Regulations 2010
- The Management of Health & Safety at Work Regulations 1999
- The Provision and Use of Work Equipment Regulations 1998
- The Personal Protective Equipment Regulations 2002
- The Control of Substances Hazardous to Health Regulations 2002
- The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013
- Dangerous Substances and Explosive Atmospheres Regulations 2002 Manual Handling operations Regulations 1992
- Genetically Modified Organisms (Contained Use) 2014
- BS EN 62471 – Photobiological safety of lamps and lamp systems
- BS EN 60825-1 – Safety of laser products. Part 1: Equipment classification and requirements
- BS EN 60825-2 – Safety of laser products. Part 2: Safety of optical fibre communication systems (OFCS)
- BS EN 60825-3 – Safety of laser products. Part 3: Laser displays
- BS EN 60825-4 – Safety of laser products. Part 4: Laser guards
- PD TR IEC 60825-8 – Safety of laser products. Part 8: Guidelines for the safe use of laser beams on humans
- BS EN 60825-12 – Safety of laser products. Part 12: Safety of free space optical communication systems used for transmission of information.
- PD TR IEC 60825-14 – Safety of laser products. Part 14: A user's guide
- BS EN 207: – Personal eye protection – filters and eye protectors against laser radiation (laser eye protectors)
- BS EN 208: – Personal eye protection – eye protectors for adjustment work on lasers and laser systems (laser adjustment eye protectors)
- Guidance on the Safe Use of Lasers in Education and Research – Association of University Radiation Protection Officers – https://aurpo.org.uk/wp-content/uploads/AURPO_Files/Guidance_Documents/2018-02-AURPO-GN7-Safe-Use-of-Lasers-in-Education-and-Research.pdf
- European Commissions non-binding guide to good practice for implementing the Artificial Optical Radiation Directive 2006/25/EC – https://publications.europa.eu/en/publication-detail/-/publication/556b55ab-5d1a-4119-8c5a-5be4fd845b68
- Laser radiation: introduction and safety advice – https://www.gov.uk/government/publications/laser-radiation-safety-advice
- PLASA Safety of Display Lasers – https://www.plasa.org/wp-content/uploads/2017/11/plasa_laser_guidance-1.pdf

10.0 Appendices

Guidance, including the risk assessment proforma, can be found at the HSD Connected Site on laser safety.

Document Control

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March 2024	Change of format to approved HSD document. Minor alternations to text order. Additions to comply with UKHSA advice. Reference to HS022 laser safety awareness.	Charles Coster, H&S Manager SAE, ULSO.	Rebecca Jones, Director HSD