Code of Practice for Working Safely with Lasers

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Code of Practice

1. SUMMARY

Lasers present a radiation hazard and can cause damage to the eyes and skin, the use of lasers can also present a range of additional significant hazards.

2. SCOPE

The aim of this document is to outline the elements of good laser practice as it applies to all lasers and their use in the University.

3. RISKS

Lasers produce electromagnetic radiation that is coherent, monochromatic and has low angular divergence, and this laser "light" can cause damage to the eye or burns to the skin and can also present a fire or explosion hazard. The magnitude of the damage is dependent on the power output of the laser which also determines the classification of the laser. Further information of classification of lasers and the optical and biological effects of lasers is given in this guidance.
The direct hazard of laser radiation is not the only risk associated with lasers. These are complex pieces of equipment that for instance can require a high voltage supply, can use highly toxic chemicals as the lasing medium, may be supplied with specialist gases and may need cooling. These supplies and the complex connections and processes involved introduce significant non-beam hazards, including mechanical and electrical hazards.

4. CONTENT

This Code of Practice sets out the standards that must be achieved for all lasers. Herein, you will be informed of your responsibilities and those of other laser workers, the Laser Supervisor (LS), Departmental Laser Safety Officers (DLSO) and the Co-ordinating Laser Safety Officer (CLSO). You will find the documentation required and compulsory training available in order to get started as a laser user. The enclosed outlines what equipment and who needs to be registered and with whom. Risk methodology for lasers is provided.

For your convenience the main implications of the laser standards and details of the new laser classes are included in this document. Also included are the contingency plans to be used in the event of an accident and these are also displayed at each laser laboratory. Further, there are details of two laser accidents at other universities. These are examples of what can go wrong when people do not follow the correct procedures.

A brief summary of the biological effects of laser radiation is given.

5. GLOSSARY OF ABBREVIATIONS

CLSO	Co-ordinating Laser Safety Officer
DLSO	Departmental Laser Safety Officer – there is one for each department with significant laser use
LS	Laser Supervisor
SOP	Safe Operating Procedure
AEL	Accessible Exposure Limits
LED	Light Emitting Diode
MPE	Maximum Permissible Exposure
NOHD	Nominal Ocular Hazard Distance
OD	Optical Density

1. RISK CONTROL STANDARD

If a department has lasers (excluding class 1 systems) then it must have

- a Departmental Laser Safety Officer (if the department has three or more lasers), and
- a Laser Supervisor for each Laser Suite within that department.

In departments with less than three lasers the Co-ordinating Laser Safety Officer will act as the DLSO.

All lasers, other than Class 1 and Class 2 must be registered with the Co-ordinating Laser Safety Officer and used in accordance with this Code of Practice. All registered lasers and their use must be risk assessed by the Laser Supervisor in line with the guidance contained in this document. All risk assessments must be checked against the requirements of BS EN 60825 as outlined in **Appendix 5.**

Before any work with lasers, all laser users must have received appropriate instruction and guidance from their Laser Supervisor, and must have confirmed that they have understood the contents of this Code of Practice and other written guidance given to them.

All lasers workers must attend training in the safe use of lasers and are required to attend refresher training every three years or after a gap greater than 6 months in which they do not carry out any laser work. Additionally all lasers users must be registered with the Health and Safety Office prior to starting work as outlined in **Appendix 1.** Registration will take place automatically for all laser workers who complete the training course.

Each laser suite containing Class 3B or 4 lasers must include a Laser Safety Information Folder. A detailed description of the required contents of this folder is given in **Appendix 3**.

The Departmental Laser Safety Officer must understand the requirements of, and ensure compliance in their Department with this Code of Practice.

All lasers must be labelled appropriately as detailed in **Appendix 12.**

Operating instructions/procedures (SOPs) must be drawn up and implemented for the safe operation of all Class 3B and Class 4 lasers that are not totally enclosed and for other lasers where there is a hazard to people if the laser is not operated appropriately.

Laser safety goggles of the appropriate type must be provided, maintained and worn as required by risk assessment, SOPs and local rules by all users working with Class 3B and 4 lasers where the beam is not totally enclosed.

Undergraduates working with lasers should be provided with the lowest power laser practicable and are required to follow a written scheme of supervised work.

Written instructions must be issued to staff or contractors (and to their managers) who have approval to enter a laser suite for specific purposes such as cleaning, waste collection and maintenance or servicing work.

When engineers come into the University to install, maintain or repair any lasers, it is essential that the Laser Supervisor obtain a copy of their risk assessment, have a protocol for hand over procedure and exclude all other workers from the area unless they are involved in the maintenance procedure. Remember that as the employer the University is responsible for handling any incident or accident involving an engineer if one should occur.

7. WHO DOES WHAT AT THE UNIVERSITY

The Vice-Chancellor has overall responsibility for ensuring the effective management of all health and safety matters including laser safety in the University.

Radiation Protection Adviser (RPA)

The University's Radiation Protection Adviser provides expert advice and consultation on the use of lasers in the University. The role of RPA is contracted to an external provider. Normally only the Head of Faculty, Coordinating Laser Safety Officer or a member of the University's health and safety team would be in contact with the RPA when additional expertise is required. If normal laser users require discussion with the RPA, this must be arranged from the CLSO.

Head of Faculty or Department

The Head of Department where lasers are used must appoint, in consultation with the Co-ordinating Laser Safety Officer:

- a Laser Supervisor for each Laser Suite, and
- a Departmental Laser Safety Officer for the department if the department has three or more lasers (excluding Class 1 lasers).

Coordinating Laser Safety Officer (CLSO)

The Coordinating Laser Safety Officer has a number of duties as outlined below.

- Approve the purchase and installation of new lasers
- Ensure that there is sufficient justification if Class 3B or Class 4 lasers are to be used without an enclosure
- Approve and sign off completed registration forms and risk assessments
- Assist Laser Supervisors in drawing up SOPs (if assistance is required)
- Provide advice on laser safety issues (inc. appropriate labelling standards)
- Keep an up-to-date record of all lasers in the university (via forms LR1 & LR2)
- Keep an up to date record of all laser users (via LR3(P) forms)
- Provide regular laser safety training courses for new laser workers
- Organise refresher training for existing or returning laser workers
- Carry out yearly inspections of all university laser suites
- Review the Laser Code of Practice document every five years (or sooner if there are significant changes to legislation)

Departmental Laser Safety Officers (DLSO)

The DLSO supports the Head of Department and the CLSO by ensuring that this Code of Practice is implemented within their Department School. The DLSO's duties are outlined below.

- Keep the CLSO is up to date with planned laser procurement of significant changes to laser suites in their department.
- Ensure that new laser workers are registered with the CLSO before the begin work
- Provide advice on completing LR1, LR2, LR3(P), LRA1 & LRA2 forms.
- Monitor the provision and use of laser safety goggles (when appropriate) by all people working with Class 3B and Class 4 lasers where the beam is not totally enclosed.
- Ensure that undergraduates working with lasers using the minimum power laser practicable and follow a written scheme of supervised work

Note that the CLSO will carry out the duties of the DLSO in Departments where there are less than three lasers.

Laser Supervisor (LS)

The Laser Supervisor should be a Research Supervisor or Principle Investigator for the laser suite. The health and safety management of individual research projects is normally delegated to the LS who have a responsibility to ensure that all work is covered by risk assessments and where appropriate by written protocols. They should also ensure that their laser workers are effectively trained in the operating techniques required and that inexperienced members of staff are adequately supervised.

The procurement of new lasers must be advised to the CLSO with full justification for requirement of new laser, and requirement for that class of laser. This must be accompanied by a completed LR1 or LR2 form and prior risk assessment for the intended use (see **Appendix 2** for guidance). Only once the CLSO has approved the procurement can the laser be purchased.

Laser Supervisors must register all their lasers (except for Class 1) with the CLSO who must update their records at the point of registration. The CLSO will store the records of registered lasers centrally. Registration is done using either the LR1 form (**Appendix 8**) or the LR2 form (**Appendix 9**), dependant on class.

The disposal of any laser when no longer required must be made in consultation with the DLSO (or CLSO) and the University Waste Administrator. The CLSO should update his register of lasers to record the disposal. Any lasers that are disposed of should be put beyond use and disposed of as electronic waste. If the lasing medium presents a hazard then it should be disposed of separately in the appropriate manner.

Laser Users

Laser Users have responsibility for their own safety and that of others who may be affected by their acts or omissions.

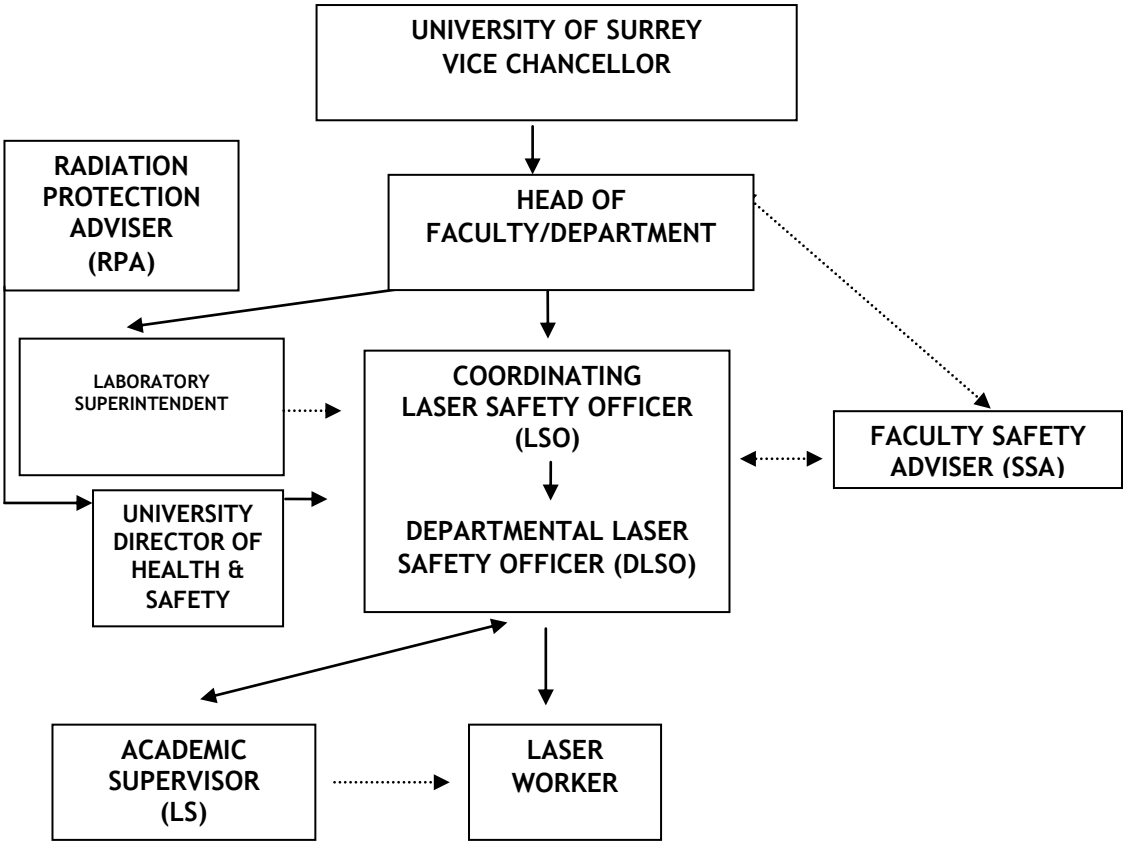
Students involved in project work and working with Class 3R, 3B or 4 lasers or modified Class 1M or 2M laser will be treated as laser workers and should be registered as such. They should also be given close supervision if working with high-powered lasers.

They must observe these Guidance Notes, any SOPs applicable to the lasers that will be used, and to follow the guidance of supervisors and the Departmental Laser Safety Officer.

Users should not leave a laser experiment running unattended unless a risk assessment has established that it is safe to do so.

When working with Class 3B or 4 lasers and there is the possibility of stray laser beams that could damage the eyes, the appropriate laser goggles **MUST BE WORN**.

8. ORGANISATION FOR LASER SAFETY



REPORTING LINE TO MANAGEMENT

LASER WORKERS MEETING/LIAISON WITH DLSO & CLSO

↓

RPS FORUM - ATTENDED BY RPA, CLSO, RPSs, DIRECTOR OF HEALTH AND SAFETY, AND FACULTY SAFETY ADVISERS

↓

UNIVERSITY HEALTH AND SAFETY EXECUTIVE COMMITTEE ATTENDED BY DIRECTOR OF HEALTH AND SAFETY AND PRO VICE CHANCELLOR FOR HEALTH AND SAFETY

↓

UNIVERSITY OF SURREY EXECUTIVE BOARD

Appendices

APPENDIX 1 - GETTING STARTED

Procurement of New Lasers

Any worker wishing to purchase or import a new laser to the University must make application to the CLSO for approval to do so. This application must be accompanied by a laser registration form (either LR1 or LR2), a prior risk assessment (form LRA1) for the intended use and location and both the justification of the requirement for a new laser and that class of laser.

Registration of Personnel - Use Form LR3(P) (Appendix 10)

All people intending to work with any class of laser, except for inherently safe Class 1 or Class 2 devices or embedded laser products such as those in laser printers or CD players, should register as a laser worker. Additionally any people who intend to use and modify Class 1M or 2M devices will also require training and full registration.

Registered users will then be issued with the appropriate general laser safety information and training by the CLSO. Additional training on the specific laser(s) that they are using should then be provided by the LS. The LS should also ensure that they receive copies of any relevant schemes of work.

Registration of Lasers

The use of lasers, except for low power Class 1 and Class 2 devices and embedded laser products such as those used in laser printers or CD players, needs to be registered with the CLSO. Form LR1 should be used to register lasers of Classes 1M, 2M and 3R (**Appendix 8**) and form LR2 for Classes 3B and 4 (**Appendix 9**). Note that multiple lasers may be registered on the LR2 form as long as they are all included in the same experiment/application.

The CLSO will then check the registered lasers to see that they are labelled in accordance with the guidance notes, operated in accordance with the guidance notes and will ensure that a suitable and sufficient SOP has been drawn up (usually by the LS) to cover their use.

SOPs are essential if you are using Class 3B or Class 4 lasers and the beam paths are not totally enclosed. They need to spell out the precautions that will be taken to ensure containment of the laser beam inside the experimental area and protection of the operatives.

Laser Safety Training

All people who will be working with any Class 3 or Class 4 laser or people who may be modifying and working on Class 1M or Class 2M devices need to attend Laser Safety training prior to the commencement of such work. This training should be repeated every three years particularly for employees with responsibility for supervising and training others. Records of training are kept by the CLSO and the Health & Safety office, and it is advised that departments keep their own records as well. Provision of a training session is given by the CLSO on behalf of the Health and Safety Office once a month to cover safe working practice, laser classification, AELs, MPEs and Risk Assessment.

Eye Examinations

Initial and routine eye examinations for laser workers are not required. However if a new laser worker has concerns about their eyesight this should be discussed with the Occupational Health Department.

Protective Equipment

If you are working with Class 3B or Class 4 lasers and the laser beam is not totally enclosed then you will probably need to wear laser safety goggles. These may also be considered necessary for work with some Class 3R lasers (invisible wavelengths). It is important that ones with the correct optical density for the laser you are using are worn. As a general rule alignment goggles – that still allow the user to see where the beam is - are recommended

for visible lasers whereas high optical density goggles should always be worn when working with invisible lasers. The goggles chosen need to conform to the appropriate standard: BS EN 207:1999 for total eye protection, and BS EN 208:1999 for alignment goggles.

If working with Class 4 lasers, and some Class 3B devices operating at UV wavelengths, you will have to consider the possible need for skin protection.

Undergraduate Work

If reasonably practicable, undergraduate work should be restricted to Class 1/1M, 2/2M or visible 3R lasers, especially for class experiments. Sometimes it is possible to downgrade a higher powered laser by the use of neutral density filters or beam expanders. It is important to introduce students to good safety practice; a written scheme of work/protocol should be drawn up and posted in the laboratory. In addition, clear written instructions should be provided for each student experiment.

Students involved in project work and working with Class 3R, 3B or Class 4 lasers or modified Class 1M or 2M lasers will be treated as laser workers and should be registered as such. They should also be given close supervision if working with high-powered lasers.

Labelling of Lasers

Inherently safe lasers in Class 1 do not need warning labels but lasers which are Class 1 by engineering design and contain an embedded laser of higher power should be labelled as 'Class 1 - Totally Enclosed System' with details of the embedded laser clearly displayed (NB this is not a BS requirement but is thought to be useful additional information). All other laser products should carry the appropriate warning labels in accordance with BS EN 60825-1. Recently manufactured lasers should all conform to this Standard. For full details of labels required see **Appendix 12**. Where lasers and laser systems are not adequately labelled (some American systems have very small labels that are hard to read and do not comply with the British Standard), labels should be obtained. Your CLSO and/or DLSO will advise on the correct labels.

Laboratory Design

The following considerations relate mainly to the use of Class 3B and 4 lasers but some may be appropriate for lower powered devices as well.

If practicable the laser laboratory should have a high level of illumination that will minimise pupil size and reduce the risk of stray laser light reaching the retina. Windows should be kept to a minimum or protected by blinds. These should be non-reflective and may need to be fireproof and/or composed of specially manufactured materials where Class 4 lasers are used.

Walls, ceilings and fittings should be painted with a light coloured matt paint to enhance illumination and minimise specular reflections. Reflecting surfaces such as the use of glass-fronted cupboards should be avoided.

Ventilation is important especially with higher-powered lasers if cryogens are used, or if toxic fumes are produced that need to be extracted and in this case it is important that the extraction is very close to the source. Facilities may also be needed for the handling of toxic chemicals that are associated with some dye lasers.

The laboratory should be equipped with appropriate fire fighting equipment.

Electrical supplies, switch and control gear should be sited in order to:-

- enable the laser to be shut down by a person standing next to the laser;
- enable the laser to be made safe in an emergency from outside the laser area;
- prevent accidental firing of a laser;
- provide an indication of the state of readiness of the laser;
- enable personnel to stand in a safe place;

- provide sufficient and adequate power supplies for all ancillary equipment and apparatus so that the use of trailing leads is minimised;
- if the laser is liquid cooled, situated in a position where they will not be effected by an accidental coolant leak.

Experimental set-up

Before starting to use your laser there are a number of basic risk reduction measures that should be considered.

- Can a lower powered laser be used?
- Can output power of laser be restricted if full power is not needed?
- Can intra-beam viewing be prevented by engineering design?
- Can laser be used in a screened off area - limiting potential for others to be affected?
- Can work be carried out in a total enclosure?
- Beam paths should be as short as possible, optical reflections should be minimised and the beam terminated with an energy absorbing non-reflective beam stop.
- Laser should be securely fixed to avoid displacement and unintended beam paths.
- If practicable align powerful lasers with low-power devices that are safe for accidental viewing, or reduce the power of the laser by turning it down or introducing neutral density filters. The aim should be to get the output power <1mw (N.B. some kW lasers will only be able to be turned down to a few watts). Alternatively remote viewing techniques can be used.
- Eliminate chance of stray reflections - use coated optical components or shroud them so that only the intended beam can be refracted or reflected. Keep optical bench free from clutter and remove jewellery, wrist watches etc.
- And don't forget to have the laser pointing away from the laboratory entrance!

Once your new laser set-up is complete the CLSO will inspect it. If he is satisfied that you have met all the safety requirements he will sign your LR1/LR2 form and you may begin work. If he is not satisfied then you may be required to make adjustments before work can begin.

Paperwork

All the paperwork pertaining to the laboratory should be kept in a Laser Safety Information folder. See **Appendix 3** for details on the folder and required paperwork.

APPENDIX 2 – LASER RISK ASSESSMENT

This appendix deals with writing risk assessments for lasers and laser processes. It includes a risk assessment template and guidance notes.

Why do I have to carry out a risk assessment?

It is important that an adequate risk assessment is carried out of every laser installation and associated equipment in each laser suite. Adequate risk assessments in the work place are a requirement of the Management of Health and Safety at Work Regulations, plus written evidence of a risk assessment will be expected by the HSE when they carry out an inspection.

When do I have to carry out a risk assessment?

If you are using a pre-existing laser set-up to perform a well documented process with its own written standard operating procedure (SOP) then you will probably not be required to carry out a risk assessment as one will already exist. If this is the case then please make sure you have read and understood it before undertaking any work.

However, if any of the following apply then you will need to carry out a risk assessment.

- You are using a new laser/laser set-up
- You are performing a new experiment/laser process
- Neither of the above apply, but no risk assessment currently exists.

How do I carry out a risk assessment?

Carrying out a risk assessment will involve considering all the potential significant hazards from a laser process, recording how the hazards are currently controlled, identifying the residual risks and deciding if further controls are required. A significant hazard is something that could cause a serious injury requiring first aid, hospitalisation, long term disability or even death. The laser risk assessment form (form LRA1) is provided on page 15 as a template to help you.

If the need for further controls is identified then these should be recorded on form LRA2, along with the target dates by which to implement them.

Identifying optical and non-optical hazards

The classification of the laser identifies the optical hazard and it is important that all other associated hazards are identified and dealt with. The manufacturer's safety guidance material should help in identifying most of the associated hazards. The main non-optical hazards to look out for are as follows:-

Electrical - high voltages and capacitors used with pulsed lasers can present a serious hazard particularly during servicing

Collateral radiation - this could include x-rays, UV, RF visible and IR radiation

Noxious fumes - can be released from the action of high power lasers used in materials processing and surgery

Hazardous substances - substances used in dye and excimer lasers can be toxic and carcinogenic, cleaning solutions may also be hazardous

Cryogenic liquids - used with high-powered lasers can present a burning hazard, possible oxygen depletion hazard and possibly an explosion hazard from over-pressure of gases in a closed system

Fire and explosion - high-powered (class 4) lasers can ignite materials and even relatively low-powered lasers (>35mW) can cause explosions in combustible gases and dusts

Mechanical hazards - from gas cylinders, trailing cables and water hoses, cuts from sharp objects, handling difficulties with large work pieces, automated mechanical or robotics system, etc

Noise - from discharging capacitor banks, from some pulsed lasers and from some air-cooled lasers

Other hazards may also arise from the environment in which the laser is used - adverse temperature and humidity, low light-level conditions, mechanical shock and vibration, interruptions to the power supply, computer software problems and ergonomic problems caused by poor design of the layout of equipment. Could cleaners inadvertently disturb equipment? Is unsupervised access allowed to the laboratory?
The people who may be at risk also need to be identified. These may include cleaning, service personnel, other contractors, visitors and the public as well as trained operatives and other laboratory users.

How serious is the hazard?

When assessing how dangerous a hazard is, it can be useful to use the scale detailed below of what would be the likely outcome if a person was exposed to the hazard.

Low – No likelihood of injury.

Medium – A reasonable chance of an injury that could result in either First Aid being required or a hospital visit as an outpatient.

Severe – A reasonable chance of an injury that could result in a long term hospital visit, temporary or permanent disability or death.

Any hazard that you would classify as medium or severe should be listed as a significant hazard on the LR1 form. Note that all hazards should be listed, even if control measures currently exist.

Which control measures?

In dealing with any hazard one should look first to eliminating the hazard if reasonably practicable and then to controlling the hazard by one of the methods listed below. They are listed in order of preference, so eliminating the hazard should always be attempted first, then, then engineering controls should be attempted next, and administrative controls should be attempted before resorting to personal protective equipment (PPE). This is sometimes referred to as the 'hierarchy of control measures'.

Eliminate - complete removal of the hazard (if practicable).

Engineering controls - features incorporated by the manufacturer or added by the user to prevent or minimise human access to hazardous levels of laser radiation. They include: beam enclosures, beam tubes, protective barriers and guards, interlocked access panels etc.

Administrative controls - include display of warning signs, local rules, schemes of work and written procedures.

Personal protective equipment - PROTECTIVE EYEWEAR SHOULD BE THE LAST RESORT and, where unavoidable, should be appropriate for the power and wavelength of the laser used and the wavelength and optical density (or scale number for CE marked eyewear) should be clearly marked. For work with visible lasers, alignment goggles are recommended that permit the safe accidental viewing of the laser light. High OD goggles should always be used when working with invisible laser beams. Visible light transmission and the ability to see warning lights are important considerations when choosing safety eyewear. If protective clothing is needed it may need to be fireproof.

The laser beam controls normally required are indicated by the laser classification. They should be implemented unless a risk assessment justifying the adoption of alternative protective control measures indicates otherwise. A summary of protective control measures is given in **Appendix 13**. Whenever deviating from the norm it is important to record your justification of the control measures adopted.

What about residual risk?

Residual risk measures the dangers associated with a hazard *after* control measures are put in place. They can be measured on the scale detailed below.

> **Low** – No likelihood of the hazard causing injury during normal operation.
>
> **Medium** – A reasonable likelihood of a hazard causing medium injury (as defined for a medium hazard) during normal operation.
>
> **Severe** – A reasonable likelihood of a hazard causing severe injury (as defined for a severe hazard) during normal operation.

Hazards that have a medium or severe residual risk will require further control measures (see the 'What comes after risk assessment?' section later).

Risk assessment for operation outside normal use

Normally the risk assessment will describe the hazards and controls in place during normal operation. However these hazards may change outside of normal operation. For example a beam that is normally enclosed may be open during maintenance, presenting a greater hazard than normal.
If you are carrying out an activity with the laser or laser process that falls outside of normal operation then you will need a new risk assessment for this stage of the laser's 'life cycle'. The life cycle can include, but is not limited to, the following stages: Installation, Commissioning, Alignment, Normal Operation, Decommissioning and Disposal.

Form LRA1 guidance notes

Assessment Number – The first assessment will always be 001. If you make further risk assessments for the same system at a later date then these will be 002, 003 and so on.

Assessed By – Your name goes here.

Life Cycle – Which part of the laser's 'life cycle' is this risk assessment for? E.g. installation, operation, maintenance, decommissioning.

Assessment/Review Date – What date was the assessment written, and what date will it be reviewed to ensure that all the findings still apply? The standard review period is one year.

Activity/Laser Suite Assessed – What is the title of the project or name of the laser suite being assessed?

Location – What is the university room number where this activity will take place?

Significant Hazards – List all the identified significant hazards here.

People at Risk – Who is at risk from each hazard?

Existing Controls – What control measures exist to mitigate these hazards?

Are These Controls Sufficient – Do the currently existing controls ensure a low risk from the hazards?

What is the Residual Risk – After the control measures have been applied, is the remaining risk for each hazard low, medium or high?

Action Required? – If the residual risk is anything other than low, then additional action will be required (see 'What comes after risk assessment?' below).

Worked example

An example of a completed LRA1 form can be found on page 19. This is shown for reference and should *not* be taken as a definitive example of all the risks involved in a laser process. The ones listed are just examples!

What comes after the risk assessment?

Once you have completed the risk assessment you may or may not have identified the need for some additional action. If any of your hazards have a medium or high residual risk then you will need to complete form LRA2, which can be found on page 16.

Form LRA2 guidance notes

Significant Hazards Identified – List each of the hazards that were identified as having medium of high risk on form LRA1.

Actions Required – Identify what action is required to reduce this residual risk to 'low'.

Date for Action – The estimated date by which this action should be completed. This should be as soon as reasonably practicable but may depend on factors beyond your control.

Completed By – The name of the person who completed the action, and the date on which it was completed.

Schemes of work

Once your risk assessment is complete then you need to make sure everyone who uses the laser/laser suite is aware of the findings. This is best achieved by producing a 'Scheme of Work' or 'local rules document'. The exact format and contents of this document is up to the individual author, but it should clearly lay out all the procedures and precautions that the users should take when working with this laser, as well as basic operating instructions for the laser and experiment itself. Schemes of Work are *compulsory* for Class 3B and Class 4 lasers.
A recommended template for a Laser Scheme of Work (form LSW1) can be found on page 17, but this *format* is not compulsorily. The contents of this template are not exhaustive, but advisory. Users should edit and rewrite it as they see fit, deleting parts that are not appropriate to their specific laser process, and adding in additional information as required. The template includes guidance notes in red, caps and square brackets. These should be deleted once the user has finished editing the form. If you submit an LSW1 form with the LR2 form to the CLSO for approval and it still contains either the guidance notes or any default information that is not appropriate then you will be asked to rewrite that LSW1 form and the approval for your new laser will be delayed.
Remember that a Laser Scheme of Work should list all controls (engineering, administrative and PPE) that are in use, and all the rules and procedures that the registered users are expected to follow. There is no point in doing the risk assessment if the laser users are not aware of the results! This is why the LSW1 template contains a section at the end for the registered users to sign to say that they have read and understood the Scheme of Work.

Ongoing risk assessment

Finally, it should be noted that with the changing nature of experimental work it is important that the risk assessment is routinely reviewed. This is why form LRA1 contains the 'Review Date' field. Of course if significant changes are made to a laser, experimental set-up or laser suite before the review date, then a whole new risk assessment will be required as the hazards and controls are likely to have changed.

LASER RISK ASSESSMENT FORM (Form LRA1)

University of Surrey

Assessment Number: Life Cycle: Assessed By: Laser Class:		Assessment Date: Review Date:		Activity/Laser Suite Assessed: Location:	
Significant Hazards	**Groups of people who are at risk**	**List existing controls**	**Are these controls sufficient?**	**What is the residual risk factor from these hazards?**	**Actions Required? (Yes/No)**

LASER RISK ASSESSMENT FORM (Form LRA2)

University of Surrey

Significant Hazards Identified	Actions Required (e.g. Control Measures to be Introduced)	Date for Action	Completed By (Name & Date)

LASER SCHEME OF WORK (Form LSW1)

This is the Laser Scheme of Work for Laboratory:	
It was issued on:	
It is due for review on:	

The users of all lasers in this laboratory should follow the scheme of work given below.

The purpose of these laser safety procedures is to ensure no-one is exposed to laser radiation in excess of the maximum permissible levels, while at the same time allowing work to be undertaken using Class [INSERT ALL RELEVANT CLASSES] lasers. If equipment is moved or new procedures become necessary, there will be a requirement to perform a new risk-assessement and, where appropriate, changes made to the Risk Assessment document (form LRA1), Laser Registration document (form LR1/2) and this Scheme of Work (form LSW1).

1. Only registered laser workers are allowed in this laser suite unaccompanied. Non laser workers must be accompanied by a registered laser worker at all times. [DELETE IF LASER IS NOT IN DEDICATED LASER SUITE OR IF LASER IS CLASS 1 OR CLASS 2]

2. Only authorised laser workers, as detailed in the "List of Authorised Users" displayed on the door of this room / adjacent to the laser [DELETE AS APPROPRIATE] are permitted to use the lasers in this laser suite

3. All users should have read and understood the details of the LR1/LR2 form, LRA1 form and LSW1 forms associated with the lasers they are using.

4. The laser worker should sign out the interlock key for the laser required. [DELETE IF THE LASER IS NOT KEY OPERATED]

5. Prior to starting the experiment, the laser worker must affix appropriate safety notice(s) on the outside of the laser suite door. [DELETE IF NOTICES ARE PERMANENT OR NOT REQUIRED]

6. The laser worker should activate the room interlock. [DELETE IF LASER CLASS DOES NOT REQUIRE ROOM INTERLOCK]

7. Confirm that the laser to be used is securely mounted and fixed in the correct position. [DELETE OR AMEND IF NOT APPROPRIATE]

8. The laser worker should check the beam path for stray objects. [DELETE IF INAPPROPRIATE OR NO ACCESS TO BEAM PATH]

9. The laser worker should confirm that the beam path enclosure is secure and external interlocks are in place. [DELETE OR AMEND IF BEAM PATH IS NOT ENCLOSED OR NO EXTERNAL INTERLOCKS ARE USED]

10. The laser power may now be powered on. It should always be powered on at the lowest possible power setting. [DELETE SECOND SENTENCE IF POWER SETTINGS ARE NOT AVAILABLE OR IF HIGHEST POWER SETTINGS ARE REQUIRED FOR START-UP]

11. Laser alignment should only be performed with the laser power at its lowest practical level / using the dedicated alignment lasers. [DELETE AS APPROPRIATE, OR DELETE

WHOLE SECTION IF ALIGNMENT IS NOT NORMALLY REQUIRED] The irradiance of the laser beam should not exceed the MPE for a Class 2 laser during alignment. [DELETE IF THIS HAS BEEN JUSTIFIED AS INAPPROPRIATE]

12. All optical alignments, tests for stray beams, placement of beam stops and preliminary tests should be performed with the laser set at the low irradiance described above. [DELETE IF NOT REQUIRED DUE TO FIXED SET-UP]

13. Once alignment is complete all protective enclosures should be returned (if they have been removed). [DELETE IF ENCLOSURES ARE NOT REQUIRED OR ARE NOT REMOVED FOR ALIGNMENT]

14. Before the intensity of the laser beam is increased, the laser worker must ensure that no stray laser radiation escapes beyond the boundaries of the laser area / set-up / optical bench / application [DELETE AS APPROPRIATE]. Beam-viewers or laser-cards should be used to trace the paths of invisible laser beams. [DELETE IF LASER BEAM IS NOT INVISIBLE]

15. Appropriate laser safety goggles must always be worn. [ADD DESCRIPTIONS OF WHICH LASER GOGGLES ARE REQUIRED OR DELETE THIS SECTION IF LASER GOGGLES ARE NOT REQUIRED]

16. Only at this stage may the beam intensity be increased to the required level for the experiment. [DELETE SECOND SENTENCE IF POWER SETTINGS ARE NOT AVAILABLE OR IF HIGHEST POWER SETTINGS ARE REQUIRED FOR START-UP]

17. If further optical adjustments are made, the intensity of the beam must be reduced to a safe level while these are carried out. [DELETE IF POWER SETTINGS ARE NOT AVAILABLE]

18. If at any time the fire alarms – or any other emergency alarm - sound then the laser worker should switch off the laser(s), remove the activation key and immediately evacuate the building in the usual way. [AMEND AS APPROPRIATE FOR LASER IN THIS LASER SUITE]

19. If an emergency occurs in the laser suite [COPY THE INSTRUCTIONS FROM PART 9 OF THE LR2 FORM HERE, OR ADD APPROPRIATE INSTRUCTIONS FOR AN EMERGENCY SHUT DOWN OF THE LASER APPLICATION]

20. If an ocular accident occurs, the laser worker must follow the contingency plans on the attached sheet. [ATTACH COPY APPENDIX 3]

21. When the laser worker has finished with the laser it is their responsibility to shut it down and remove any warning signs from the door / deactivate interlock. [DELETE AS APPROPRIATE]

22. The laser worker should return the activtation key and sign it back in. [DELETE IF THE LASER IS NOT KEY OPERATED]

Once you have read and understood this Scheme of Work, please fill in your details below. By signing this document you are agreeing to abide by the working practices that it describes.

Laser Worker Name	Laser Worker Signature	Date

WORKED EXAMPLE - LASER RISK ASSESSMENT FORM (Form LRA1) – *WORKED EXAMPLE*

Assessment Number: *001* Life Cycle: *Normal use* Assessed By: *John Smith* Laser Class: *3B*		Assessment Date: *April 2011* Review Date: *April 2012*		Activity/Laser Suite Assessed: *Laser Experiment* Location: *Generic Lab 01*	
Significant Hazards	**Groups of people who are at risk**	**List existing controls**	**Are these controls sufficient?**	**What is the residual risk factor from these hazards?**	**Actions Required? (Yes/No)**
Laser					
Eye damage from laser emissions	*Operator, other lab users*	*Laser emissions not accessible during normal use (engineering)*	*Yes*	*Low*	*No*
High voltage power supply	*Operator, other lab users*	*HV components not accessible during normal use (engineering)*	*Yes*	*Low*	*No*
Beam Delivery					
Eye damage from laser beam	*Operator, lab users*	*Laser beam contained within metal tube (engineering)*	*Yes*	*Low*	*No*
Laser Process					
Laser heats sample, possibility of fire or fumes	*Operator, lab users*	*Lowest practical power used as dictated in experiment SOP (admin)*	*Yes*	*Low*	*No*
Environment & People					
Laser beam 'escaping' through laboratory window	*Members of the public*	*Beam contained within metal tube and protective material blocks windows (engineering)*	*Yes*	*Low*	*No*
Exposure of cleaners or unauthorised/unexpected laboratory visitors	*Cleaners, members of the public, other staff members*	*Swipe card system and laser hazard warning light prevent/discourage entry. Interlock ensures the beam is blocked if lab door is unexpectedly opened (engineering)*	*Yes*	*Low*	*No*

APPENDIX 3 – LASER SAFETY INFORMATION FOLDER

The Laser Safety Information folder should be a standard A4 sized folder labelled as 'Laser Safety Information' or similar. It is recommended that the folder is red or another high visibility colour, but this is not essential.

The folder should be divided into eight sections, labelled as follows. It is also acceptable for these sections to be placed within a general laboratory health and safety folder, so long as they are still clearly labelled and the folder is easily identifiable as containing the laser safety information.

1. Scheme of Work – Form LSW1 (see **Appendix 2**).

2. Laser Operating Instructions – Copies of any standard operating procedures, instructions or manuals that exist for the lasers in the laboratory.

3. Laser Risk Assessments – Copies of forms LRA1 and LRA2 (if appropriate) for all lasers in the laboratory (see **Appendix 2**).

4. LR1 Forms – Copies of the LR1 form for all lasers in the laboratory (see **Appendix 8**).

5. LR2 Forms – Copies of the LR2 form for all lasers in the laboratory (see **Appendix 9**).

6. Contingency Plans – A copy of the Ocular Accident Contingency Plans (see **Appendix 4**).

7. Copy of Laser COP Document – A copy of this Laser Code of Practice document.

8. Laser Survey Form – A copy of the Laser Survey Form (see **Appendix 14**).

Please note that the folder should contain *fully completed* copies of all the forms specified. In the event of a safety inspection viewing these folders will often be the first activity carried out by the inspectors.

APPENDIX 4 – OCULAR ACCIDENT CONTINGENCY PLANS

Any laser incident or accident must be reported to the Coordinating Laser Safety Officer and the Faculty Safety Adviser. A University Incident Report Form must be completed and sent to the Health and Safety Office.

For Ocular Injury Accident

Following an incident/accident any equipment must be isolated pending investigation. If ocular exposure has occurred, a full investigation into the cause and nature of the exposure must be undertaken and recorded in full.

If there is suspected injury to the eye, the injured person should see a specialist ophthalmologist at the Royal Surrey County Hospital within 24 hours. The injured person should not drive and should be accompanied by a colleague who is not also injured.

The Laser Safety Officer must report any injury to the Occupational Health Department to ensure follow up for the injured person.

If an ophthalmologist is not available at the RSCH, the injured person should be sent within 24 hours to Moorfields Eye Hospital where the medics are experienced in dealing with laser eye injuries.

Details of the laser beam should accompany the casualty to hospital. These should include type of laser system, classification, wavelength, power/energy per pulse and pulse duration. You should have a copy of this page readily available in your laser suite in case of an accident. The details of the laser can be recorded below so the injured person and his/her colleague can take this page with them.

Royal Surrey County Hospital
Accident and Emergency Department open 24 hours a day
Address: Egerton Road, Guildford, GU2 7XX
Telephone Number: 01483 571122

Moorfields Eye Hospital
Accident and Emergency Department open 24 hours a day
Address: 162 City Road, London, EC1V 2PD
Nearest Underground Station: Old Street, Northen Line
Telephone: 020 7253 4696
Location and directions to A&E department available at
http://www.moorfields.nhs.uk/Publicationsandresources/Locationmapsanddirections#md1

Laser Details

Laser System:	
Classification:	
Wavelength:	
Power/Energy per Pulse:	
Pulse Duration:	

APPENDIX 5 – LEGISLATION AND STANDARDS FOR LASERS

The safety of laser products is covered by BS EN 60825-1:2007. This BS is a `euronorm' based upon the International Electrotechnical Commission's IEC 60825-1. The 60825 standard encompasses a range of standards for manufacturer's and users on lasers, fibre optic systems, safety eyewear, laser guards, components etc.

The 'Control of Artificial Optical Radiation at Work Regulations 2010' is a European Directive on the minimum health and safety requirements for workers exposed to artificial optical radiation. It was transposed into UK law in April 2010. Legally-binding exposure limits now apply for worker exposure to laser radiation, but these are identical to the MPEs defined in 60825-1. This regulation also includes the requirement to carry out risk assessment for artificial optical radiation sources.

Of particular importance for users is the Technical Report PD IEC/TR 60825-14:2004 which is a detailed user's guide that incorporates a risk assessment approach to laser safety. You are advised to refer to this document if you are seeking further guidance on determining MPEs (maximum permissible exposure levels), evaluating risk, control measures, interlock systems, calculations and biophysical considerations. There is also software available from the CLSO to aid in calculating MPEs.

All the British Standards on laser safety are available online and your CLSO, DLSO or LS will direct you to the relevant website.

APPENDIX 6 - LASER CLASSIFICATION

LASER stands for Light Amplification by the Stimulated Emission of Radiation but is defined in BS EN 60825 as 'any device that can be made to produce or amplify electromagnetic radiation in the wavelength range from 180nm to 1mm primarily by the process of controlled stimulated emission'. LEDs were included in the scope of previous editions of 60825-1, however these are now covered by lamp safety standards and are no longer covered by laser safety standards.

The higher the class of laser the greater the optical hazard it presents. The classification is based upon the measured radiation through a given aperture at a set distance (see section 9 of BS EN 60825-1:2007), and AELs (Accessible Emission Levels) have been set for each class of laser (see Tables 4-10, p43-49 BS EN 60825-1:2007). In the class descriptions below the lasers can be of any wavelength within the full range (i.e. 180nm to 1mm) unless a restriction is stated.

Class 1 Lasers

The AEL is less than or equal to the MPE.

These are normally safe to both skin and eye either because of their inherently low power or because they are a totally enclosed system where access to higher levels of laser radiation is not possible during normal operation. However if access panels of a totally enclosed system are removed for servicing, etc, then the laser product is no longer Class 1 and the precautions applicable to the embedded laser must be applied.

Class 1M Lasers

These are laser products, emitting in the wavelength range 302.5nm to 4000nm, whose total output is in excess of that normally permitted for Class 1 laser products but because of their diverging beams or very low power density do not pose a hazard in normal use and satisfy the measurement conditions for a Class 1M product. However they may be hazardous to the eyes under certain conditions if gathering optics (magnifying products) are used with them:-

a) With a diverging beam if optics are placed within 100mm of the source to concentrate/collimate the beam.

b) With a large diameter collimated beam viewed with binoculars or a telescope.

Class 2 Lasers

These are laser products that only emit visible radiation in the wavelength range 400nm to 700nm and whose output is less than the appropriate AEL. They are safe for accidental viewing as protection is afforded by the aversion and blink responses (for exposures less than 0.25 seconds). There is no hazard to the skin.

Class 2M Lasers

These are laser products that only emit visible radiation in the wavelength range 400nm to 700nm, whose total output is in excess of that normally permitted for Class 2 laser products but because of their diverging beams or very low power density are safe for accidental viewing during normal use and satisfy the measurement conditions for a Class 2M product. However they may be hazardous to the eyes under certain conditions if gathering optics (magnifying products) are used with them:-

A) With a diverging beam if optics are placed within 100mm of the source to concentrate/collimate the beam.

b) With a large diameter collimated beam viewed with binoculars or a telescope.

Class 3R Lasers

These are laser products that present only a low risk of eye damage as their output is restricted to no more than 5 times the AEL for visible Class 2 lasers (5 x 1 mW = 5mW) or no more than 5 times the AEL for Class 1 devices at other wavelengths. Direct eye exposure should be prevented. There is no hazard to the skin.

Class 3B Lasers

These are laser products that are hazardous to the eye for direct intrabeam viewing and from specular reflections but diffuse reflections are normally safe unless you are close to the beam (less than 13.5 cm away). They may be hazardous to the skin at some wavelengths at the upper limit of the class. Output levels must be less than the appropriate AEL for Class 3B devices. Maximum power is 500 mW.

Class 4 Lasers

These are high power devices that exceed the AELs for Class 3B devices and are always hazardous to the eyes and skin from direct viewing and from specular reflections. Diffusely reflected beams should be assumed harmful to the eyes and skin unless proven otherwise by risk assessment. Both direct and scattered beams have sufficient energy to ignite materials and produce hazardous fumes. Their use requires extreme caution.

Example AELs

The AELs for He-Ne lasers emitting a narrow beam in Continuous Wave mode at 632.8nm are as follows:

- Class 1 & 1M 0.25 mW
- Class 2 & 2M 1 mW
- Class 3R 5 mW
- Class 3B 500 mW

These limits will also apply to other narrow beam CW lasers operating in the wavelength range 400-700nm except for Class 1 and 1M devices where there are further restrictions for wavelengths 400-500nm. See BS EN 60825-1:2007 for full details.

APPENDIX 7 - MAXIMUM PERMISSIBLE EXPOSURE LEVELS (MPEs)

MPEs reflect the current state of our knowledge in relation to the hazard posed by laser radiation to different biological tissues. It is obviously important to know what levels of laser radiation are considered to be safe and MPEs represent the maximum level to which eye or skin can be exposed without suffering short or long-term damage. With the use of appropriate safety factors (to take into account the possibility of photosensitivity in the subject, etc) MPEs have been established for two different scenarios:

- direct ocular exposure - intrabeam viewing
- exposure of the skin.

MPEs vary according to the wavelength, exposure time, tissue at risk and, for visible and near infra-red radiation, the size of the retinal image. For MPEs and tables of values see p57-59 of BS EN 60825-1:2007 or p49-52 of PD IEC TR 60825-14:2004.

Examples of MPEs for a Continuous Wave He-Ne laser operating at 632.8nm are as follows:

- intrabeam viewing 0.63 $mW.cm^{-2}$
- skin exposure 778 $mW.cm^{-2}$

APPENDIX 8 – LASER REGISTRATION FORM LR1

Laser registration form LR1 can be found on the next page. This form is for registering lasers of class 1M, 2M and 3R.

Guidance on completing form LR1

Department – Which department owns the laboratory in which the laser will be used? This should be the sub department rather than the faculty, e.g. Physics rather than FEPs for example.

Laboratory – The room number and name (if applicable) of the laboratory in which the laser is used.

Responsible Person – The name of the laser supervisor for the laboratory listed above.

Make, Model and Serial Number – The name of the laser manufacturer, the model or the laser and its serial number.

Laser Details – This should be a brief description of the laser, including any noteworthy details that have not been listed elsewhere in this form.

Class – The class of the laser, as provided by the manufacturer or as determined by yourself if you have modified the laser to be used in a way other than intended by the manufacturer. The BS/EU class should be listed (in numbers) rather than the American class (in Roman numerals).

Lasing medium – What material is the laser based around? E.g. Helium Neon.

Wavelength range – What is the full range of wavelengths the laser is capable of producing? This should always be the full range, not just the range that you intend to use. If the laser only outputs at a single wavelength then just list that.

Mode of operation – Does the laser operate as Continuous Wave (CW), Pulsed or both?

Maximum power / pulse energy – List the maximum power for the laser if CW or the maximum pulse energy if pulsed. Again, this should be the maximum that the laser is capable of outputting rather than the maximum that you are intending to use.

Initial beam diameter – The diameter of the beam at the laser aperture. If the beam is elliptical then please enter the x and y diameter of the beam. Remember to include your units.

Beam Divergence – The divergence of the laser beam in radians. This information should be available from the manufacturer.

Brief Description of Use – What do you plan to use the laser for?

Risk Assessment – A risk assessment of the activity should be attached to the LR1 form. For details of carrying out risk assessments please see **Appendix 2**.

LASER REGISTRATION (Form LR1)

LASER REGISTRATION FOR CLASSES 1M, 2M & 3R

University of Surrey

Department:	
Laboratory:	
Responsible Person (Laser Supervisor):	
Make, Model and Serial Number:	
Laser Details: Class:	Lasing medium: Wavelength range: Mode of operation: Maximum Power/ Or pulse energy: Beam Diameter: Beam Divergence:
Brief Description of Use: (Attach Risk Assessment)	
Signature:	Date:
Registration and Risk Assessment Approved Signature of CLSO or DLSO:	Date:

FOR SAFETY OFFICE USE	
LASER CLASS	**Date Inspected**
Signature CLSO:	

APPENDIX 9 - LASER REGISTRATION FORM LR2

Laser registration form LR2 can be obtained from the sources listed below. This form is for registering lasers of class 3B and 4.

Where to obtain Form LR2

Form LR2 can be obtained from either the CLSO or your DLSO (where applicable).

Guidance on completing form LR2

Department – Which department owns the laboratory in which the laser will be used? This should be the sub department rather than the faculty, e.g. Physics rather than FEPs for example.

Laboratory – The room number and name (if applicable) of the laboratory in which the laser is used.

Responsible Person – The name of the laser supervisor for the laboratory listed above.

Part 1. Laser Identification and Specifications

Laser Medium – What material is the laser based around? E.g. Helium Neon.

Manufacturer – The name of the company who manufactured the laser.

Model – The model name of this laser.

Serial Number – The unique serial number of this laser, normally found on the casing or sometimes in the accompanying documentation. If the laser head and laser power supply have separate serial numbers then please list both.

Maximum Power - List the maximum power output of the laser. This should be the maximum that the laser is capable of outputting rather than the maximum that you are intending to use. For a pulsed laser this is the *average* maximum pulse power, not the peak.

Maximum Pulse Energy – List the maximum pulse energy of the laser. This should be the maximum that the laser is capable of outputting rather than the maximum that you are intending to use. Mark 'N/A' if not a pulsed laser.

Wavelength Range – What is the full range of wavelengths the laser is capable of producing? This should always be the full range, not just the range that you intend to use. If the laser only outputs at a single wavelength then just list that.

Wavelength Used – What wavelength or wavelength range will you be using in your experiment or activity?

Power Used - What power or power range will you be using in your experiment or activity?

Pulse Energy Used – What pulse energy or pulse energy range will you be using in your experiment or activity? Mark 'N/A' if not a pulsed laser.

Pulse Duration – What is the duration or the laser pulse? This value is normally given in seconds. Mark 'N/A' if not a pulsed laser.

Pulse Repetition Rate – At what frequency do the laser pulses repeat? This value is normally given in hertz. Mark 'N/A' is not a pulsed laser.

Beam Diameter(s) – The diameter of the beam at the laser aperture. If the beam is elliptical or rectangular then please enter the x and y diameter of the beam. Remember to include your units.

Beam Shape – What shape is the beam at the laser aperture? E.g. circular, elliptical, rectangular, etc.

Beam Divergence – The divergence of the laser beam in radians. This information should be available from the manufacturer. If the beam has different rates of divergence in the x and y planes then please list both values.

Laser Class - The class of the laser, as provided by the manufacturer or as determined by yourself if you have modified the laser to be used in a way other than intended by the manufacturer. The BS/EU class should be listed (in numbers) rather than the American class (in Roman numerals).

Part 2. Description of Activity or Research Project

This section should include one or two paragraphs giving a brief description of how the laser will be set-up within the laser suite, what experiment or activity is being attempted with the laser and what you are trying to achieve. You may include a diagram if you wish.

The duration of the activity can be listed as a finite number of months or year, or simply as 'ongoing' if the set-up is essentially permanent.

Part 3. Identification of Non-Beam Hazards

This section lists potential non-beam hazards that may be attached to a Class 3B or 4 laser. It is intended to make you consider what extra hazards there might be beyond the danger of the laser beam itself. If you do not believe a particular hazard applies to your laser then you may simply answer 'No'. However if a hazard does apply, please give a more detailed answer beyond 'Yes', e.g. if toxic gases are present, which gases are they?

In a multiple laser set-up, some of these non-beam hazards may apply to only some of the lasers and not others. If this is the case please indicate to which laser your answer(s) apply.

Part 4. Identification of People at Risk

This section requires you to list the people who might be at risk from beam and non-beam hazards. You may list them by name in the case of known colleagues (e.g. Alice, Bob, etc) or by group if not known (e.g. other laboratory users, cleaners, etc). Remember to consider the possibility of unexpected visitors as well as the people who regularly use the laboratory.

Part 5. Risk Assessment

This section requires you to attach a completed LRA1 form, which can be found along with guidance notes in **Appendix 2** of this document. The information you have already entered in parts 3 and 4 for the LR2 form will help you complete the risk assessment.

Part 6. Control Measures and Scheme of Work

This section requires you to identify any circumstances under which your laser will be used with an open or partially enclosed beam. If your application has neither then you may just answer 'NO'. If open or partially enclosed beams are present then you *must* have a written protocol (Scheme of Work) detailing the control measures used to make the beam safe to work with. See **Appendix 2** for guidance notes of Schemes of Work.

Part 7. Authorised Users and New User Training

Here you are required to list the laser workers who will initially be authorised to use the laser. Additional users can of course be added at a later date. You will also be required to list the people who will be authorised to train new users. Normally this will be the Laser Supervisor, but he/she may wish to appoint particularly competent users as being able to also deliver training.

A list of authorised users is required to be present in close proximity to the laser, or on the entrance to the laser suite. If you answer 'NO' to the presence of the user list then you will be asked to produce one before the CLSO signs off the form.

Part 8. Protective Eyewear

This section is used to list the protective eyewear that is available for use with the lasers detailed in part 1.

Manufacturer - The name of the company who manufactured the laser goggles.

Wavelength – The wavelengths over which the goggles are designed to function, as indicated on the goggles. It is probable that the goggles may function over several different ranges, so please list them all.

Optical Density – The Optical Density (OD) of the laser goggles, as indicated on the goggles. This is likely to vary across different wavelengths, so please list the appropriate OD value next to each wavelength range listed in the previous column.

Number Available – How many pairs of these goggles are available?

Location Stored – Where are the goggles stored when not in use? Ideally this should be a location that is accessible without entering the laser suite or laser controlled area, so that users may put on the goggles without accessing the hazard area.

Part 9. Emergency Action

This section requires you to list the measures that need to be taken to eliminate all beam and non-beam hazards in the event of an emergency, e.g. personal injury, fire, chemical leak, etc. This may be as simple as pressing an emergency stop button to immediately terminate power to the laser, or it may be a more involved procedure. Please bear in mind that these are *emergency* procedures and should be designed to eliminate hazards to personal above hazards to equipment. Sometimes a quick shutdown might be harmful to a laser system, but in an emergency it must be carried out anyway.

The second part of this section asks you to list any other action that may be required to make the laser suite safe for the Emergency Services to enter. Often there will not be any additional instructions for them, but sometimes there might be additional measures required to make the suite safe for fire fighters, for example.

Part 10. Emergency Contact

This section will normally list the details of the Laser Supervisor (so in this case 'Position' will be 'Laser Supervisor') and a mobile telephone number where he/she can normally be reached in the event of an emergency, especially an out of hours emergency. However in some circumstances another person may be nominated. Just make sure that he/she agrees first! In this case 'Position' should list their job title, such as 'Technician' or 'Research Associate', etc.

Part 11. Monitoring of Control Measures

The person named in this section will normally be the Laser Supervisor. A frequent laser suite user could be named instead (if they agree), but the ultimate legal responsibility would still rest with the Laser Supervisor; the user would effectively be reporting to them. The person named in this section will need to report to the Laser Supervisor if they believe any control measures have ceased to be effective for whatever reason. This could be mechanical failure on engineering controls, damaged laser goggles, etc. It can be a good idea to make the checking of control measures a regularly scheduled event.

Part 12. Review of Risk Assessment

When you completed your risk assessment form LRA1 you should have decided on a review date. The information on form LR2 should also be reviewed on this date. If the review reveals that the information on the form needs to be updated then please complete a new LR2 form and submit it to your CLSO for approval.

You will also need to list any conditions that might require an earlier review, e.g. the end of a project or significant changes to the set-up.

Signatures

Once the form is complete the Laser Supervisor should sign and date in this box. The CLSO will also sign and date the form once they have approved the paperwork (you are then free to purchase your laser) and checked that the laser is properly installed in the laser suite (you are then free to begin work).

APPENDIX 10 - PERSONAL REGISTRATION FORM LR3(P)

All prospective users of lasers except undergraduate students working in set laboratory classes must complete this form before work starts. Users include employees, students and visitors carrying out experimental work under contract or otherwise.

Guidance on completing form LR3(P)

1. Personal Details

Enter the personal details requested. Note that you should supply a phone number on which you can be contacted while you are at the University, such as a mobile number or office number. Please do not list home numbers. The same applies to the e-mail address that you provide.

2. Work Details

A brief description of the project in which you are planning to use lasers, including an estimate start and finish date. If a finish date is not known or the project is ongoing then please state this.

3. Previous Laser Experience

Please list any other establishments where you have previously worked with lasers.

4. Conditions Applying to Registration

Once you have completed the form please sign it and have your Laser Supervisor sign it. Your Laser Supervisor will be the supervisor of the laser laboratories in which you are planning to work. If you are planning to work in more than one laser laboratory then you only need to obtain the signature of the supervisor for the laboratory where you will spend the majority of your time.
Note that your Laser Supervisor should sign the form *before* you attend the Laser Safety Training course. On completion of the course the CLSO will then sign and retain your LR3(P) form.

LASER WORKER PERSONAL REGISTRATION (Form LR3(P))

UNIVERSITY OF SURREY RADIATION PROTECTION SERVICE PERSONAL REGISTRATION FORM

University of Surrey

1. PERSONAL DETAILS

Surname:	Forename(s):	Title:
Faculty and Department:	University Library No:	Date of Birth:
Work Phone or Extension No:	E-mail Address:	Staff/UG/PG/Visitor:

2. WORK DETAILS

Description of Work and/or Project Title:	
Planned Start Date:	Expected Finish Date:

3. PREVIOUS LASER EXPERIENCE

Establishment and Address:	Description of Work:	Period:

4. CONDITIONS APPLYING TO REGISTRATION

I have read and understood the University Code of Practice for Safe Working with Lasers. I agree to not commence work with lasers until I have undertaken mandatory training provided by the Coordinating Laser Safety Officer and also received details of Local Rules and Special Operating Procedures that may apply to my work area(s) from my Laser Supervisor(s). I agree that I will comply with them once given.

Signature: _____ Date: _____

As Laser Supervisor I agree that I will provide details of Local Rules and Special Operating Procedures that may apply to the work area(s) of the above Laser Worker before they commence work.

Laser Supervisor Signature: _____ Date: _____

As CLSO I confirm that the above has received the mandatory training on the Safe Use of Lasers.

CLSO Signature: _____ Date: _____

The Coordinating Laser Safety Officer will retain a copy of this form and send a copy to the Health and Safety Office.

CLSO Comments:

APPENDIX 11 - WHO DOES WHAT IN LASER SAFETY AT SURREY

This checklist is intended as a guide to actions required by Laser Users, Laser Supervisors and other members of the laser safety community. The list is not intended to be definitive but acts as a quick reference for compliance with this Code of Practice document. There may be further actions required by the users, supervisors, and officers in compliance with Faculty or Department safety strategies.

Action	Laser User	Laser Supervisor	DLSO	CLSO
Advise DLSO/CLSO of new laser or modification to existing one.		X	X	
Complete registration forms LR1or LR2 along with risk assessment, SOP and Safety Rules and send copies to CLSO.		X		
Provide Laser Safety Training for new laser users.				X
Enrol on Laser Safety Training course.	X			
Complete personal registration form LR3(P) and bring to Laser Safety Training course.	X			
Retain Risk assessment form for the information of all users and to be available for HSE inspection		X		X
Check risk assessment and new laser set-up BEFORE any work commences. Sign off if satisfied.			X	X
Advice on laser eye protection.			X	X
Read and understand Guidance notes, SOP and local rules for the laser suite in which they will be working.	X			
Advice supervisor and occupational health on any eye defects other that short sight	X			

APPENDIX 12 - LASER SIGNS AND LABELS

Designated Laser Areas

The points of access to areas in which Class 3B or Class 4 laser products are used must be marked with warning signs complying with BS 5378. The signs shall incorporate the following information:

1) hazard warning symbol (detailed spec on p26 of BS EN 60825-1:2007)

2) highest class of laser in the area

3) responsible person with contact details

Laser Labels

Laser labels are required for all laser products except for low power Class 1 devices. They are designed to give a warning of laser radiation, the class of laser, basic precautions and the laser's characteristics.

The laser warning uses the same symbol as for the door sign in an appropriate size for the laser to be labelled and should be clearly visible. Supplementary information should be black text on a yellow background in accordance with Fig 2 p27 of BS EN 60825-1:2007.

Where the size of the laser product does not permit the affixing of a reasonably sized label then a sign should be displayed in close proximity to the laser with all appropriate information on.

Details of wording required on explanatory labels for each of the Classes is given below. Normally all the labels described in this appendix will be attached by the manufacturer, but if this is not the case then it is up to the laser purchaser to attach suitable versions of their own.

Class 1

No laser hazard warning symbol.

Explanatory label bearing the words:

CLASS 1 LASER PRODUCT

Additional information is required for products that are Class 1 by engineering design giving details of the risk of exposure if panels are opened, etc. Details of the required information can be found on p30 of BS EN 60825-1:2007.

Class 1M

No laser hazard warning symbol.

Explanatory label bearing the words:

LASER RADIATION
DO NOT VIEW DIRECTLY
WITH OPTICAL INSTRUMENTS

CLASS 1M LASER PRODUCT

The words 'OPTICAL INSTRUMENTS' can be supplemented with either 'BINOCULARS OR TELESCOPES' for a large diameter collimated beam or 'MAGNIFIERS' for a highly diverging beam.

Class 2

Label with laser hazard warning symbol.

Explanatory label bearing the words:

LASER RADIATION
DO NOT STARE INTO BEAM
CLASS 2 LASER PRODUCT

Class 2M

Label with laser hazard warning symbol.

Explanatory label bearing the words:

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

The words 'OPTICAL INSTRUMENTS' could be replaced with either 'BINOCULARS OR TELESCOPES' for a large diameter collimated beam or 'MAGNIFIERS' for a highly diverging beam.

Class 3R

Label with laser hazard warning symbol.

Explanatory label bearing the words:

LASER RADIATION
AVOID DIRECT EYE EXPOSURE
CLASS 3R LASER PRODUCT

The words 'AVOID DIRECT EYE EXPOSURE' could be replaced with 'AVOID EXPOSURE TO BEAM' is desired.

Class 3B

Label with laser hazard warning symbol.

Explanatory label bearing the words:

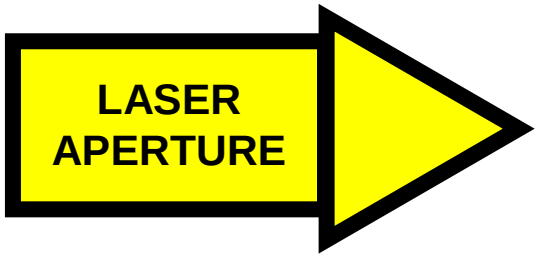
Class 4

Label with hazard warning symbol.

Explanatory label bearing the words:

Aperture Labels for Class 3R, Class 3B & Class 4 lasers

Each Class 3R, Class 3B and Class 4 laser product shall have affixed a label close to each aperture through which laser radtion is emitted bearing the words 'LASER APERTURE' or ‘APERTURE FOR LASER RADITION’ or 'AVOID EXPOSURE - LASER RADIATION IS EMITTED FROM THIS APERTURE'. This label can take the form of an arrow if desired:



Radiation Output and Standards Information

All laser products, except for Class 1 devices, shall have an attached explanatory label which includes the following information:

- maximum output
- emitted wavelength
- whether laser is visible, invisible or both
- pulse duration (if applicable)
- name and publication date of classification standard

In addition the labels may also include details of the type of laser and the lasing medium. This is not required, but is advisable.

APPENDIX 13 – SUMMARY OF WARNINGS & PROTECTIVE MEASURES

CLASS	PROTECTIVE CONTROL MEASURES
1	No protective control measures for normal use (NB special precautions may be needed for service work on embedded laser products.)
1M	Prevent direct viewing with magnifying optics. (NB fitting external optics that decrease beam divergence may affect classification) + *see footnote*
2	Do not stare into beam. Do not direct the beam at other people or into public areas.
2M	Do not stare into beam Do not direct the beam at other people or into public areas. Terminate beam at end of useful path with a non-specular beam stop. Prevent direct viewing with magnifying optics. (NB fitting external optics that decrease beam divergence may affect classification) + *see footnote*
3R	Prevent direct eye exposure to the beam. Do not direct the beam at other people or into public areas. + *see footnote*
3B and 4	Class 3B and Class 4 laser products should not be used without first carrying out a risk assessment to determine the protective control measures necessary to ensure safe operation. Where reasonably practicable engineering means should be used reduce the laser class to a totally enclosed Class 1 laser product. The use of any Class 3B or Class 4 laser without an interlocked enclosure will require a written scheme of work. Even with an enclosure written procedures may be necessary especially if the user is involved in any alignment procedures that require over-riding of interlocks. Class 3B and Class 4 laser products require the control of access to the area where the laser is operated by the use of a remote interlock, the use of key control, emission indicators, beam shutters, removal of reflecting surfaces from near the beam path, beam enclosures wherever practical, the use of eye protection and protective clothing as appropriate, training of staff and the appointment of a Laser Safety Officer.

+ Classes 1M, 2M and 3R may also require training of staff, care with beam paths and specular reflections - see BS EN 60825:2007 and PD IEC TR 60825-14:2004 for more details.

Special attention should also be given to other non-optical hazards such as risk of electric shock, hazardous chemicals, cryogenic liquids and flying debris from targets to name but a few. It is often the non-optical hazards that pose the greatest risk - one could be blinded in one eye from a powerful laser but electrocution could be fatal. Some non-optical hazards may be present with even Class 1 laser products.

APPENDIX 14 - SUMMARY OF BS EN 60825-1 MANUFACTURER & USER REQUIREMENTS

REQUIREMENT	CLASS
Remote Interlock Connection	Connection provided by the **manufacturer** for door or enclosure interlock for Class 3B and Class 4 lasers.
Safety Interlocks	Provided by **manufacturer** for access panels on Class 3R, 3B and 4 laser systems.
Key Control	A key or similar device is required to control access to Class 3B or4 lasers. The laser should be inoperative when the key is removed. Normally provided by **manufacturer**.
Emission Indicator	An audible or visible indicator should be provided by the **manufacturer** for each Class 3R (invisible wavelengths only), Class 3B and Class 4 laser system to indicate when the laser is switched on, or when the capacitor banks are charging in the case of a pulsed laser.
Beam Attenuator or Shutter	Should be provided by the **manufacturer** for each Class 3B or Class 4 laser system as a means of temporarily blocking the laser beam.
Beam Termination	The **user** should ensure that all beam paths are terminated at the end of their useful path. Does not apply to Class 1 devices.
Beam Level	The **user** should endeavour to set-up the laser so that the beam is not at eye level.
Beam Enclosure	Provided by the **user** to guard against specular reflections from Class 3R, Class 3B and Class 4 lasers - can mean anything from screening the experimental area or piping the beam up to a total enclosure.
Eye Protection	Required for open beam work with invisible Class 3R and all Class 3B and Class 4 devices. Normally provided by the **user**.
Protective Clothing	Mainly required for Class 4 lasers but be careful with Class 3B UV lasers as well, may need fire resistant material for some lasers. Normally provided by the **user**.
Eye Examinations	Only required after an accident but may be important to people with poor eyesight working with Class 3B or Class 4 lasers. This is the **user's** responsibility.
Training	Required for people working with any Class 3 or Class 4 laser and any modified Class 1M or Class 2M devices. Enrolling is the user's responsibility.
Laser Labels	Required for all lasers except low power Class 1.
Door/Area Signs	Required for Class 3B and Class 4 lasers indoors and also for Class 1M, 2M and 3R if used outdoors.

Laser Survey Form

The following laser survey form takes all the above manufacturing and user requirements into account and provides a checklist to see if the laser installation is observing all the requirements recommended by BS EN 60825. This can be used to double check that everything has been covered when completing form LR1 or LR2, or as part of a safety audit by an LS, DLSO or CLSO. Grey boxes indicate that the precaution is not required for that class of laser.

Where a box cannot be 'ticked off' the user should be employing some other protective measure justified by a risk assessment.

LASER SURVEY FORM		**DEPT:**			
Date:		**LAB N°:**			
Manufacturer:		**Laser Medium:**		**Mode:**	
Model & Serial Number:		**Wave length:**		**Max Power:**	

PRECAUTIONS	**1M**	**2**	**2M**	**3R**	**3B**	**4**	**1(E)***
Remote Interlock							
Safety Interlocks							
Key Control							
Emission Indicator							
Beam Attenuator/Shutter							
Beam Terminator							
Beam Level							
Beam Enclosure							
Eye Protection							
Protective Clothing							
Eye Examinations							
Training							
Laser Labels							
Door/Area Signs							

**Class 1(E) Lasers those that are Class 1 by engineering only, not due to inherently safe power levels.*

Laser installation: SATISFACTORY / NOT SATISFACTORY (Delete as appropriate)

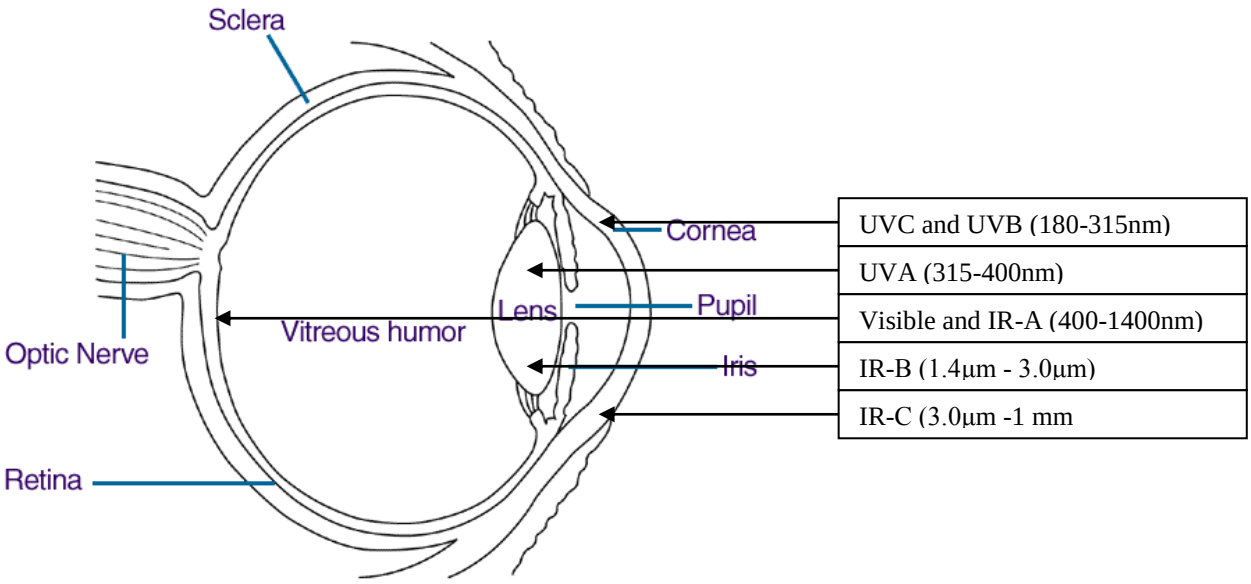
Additional control measures required:

.....
.....
.....
.....
.....

Survey performed by: .....

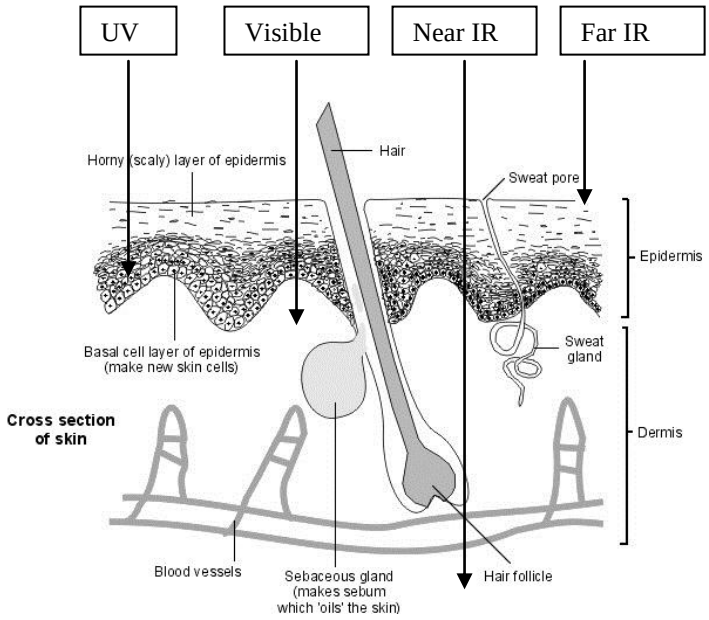
APPENDIX 15 - OPTICAL HAZARDS & BIOLOGICAL EFFECTS OF LASER RADIATION

Penetration of laser radiation into the eye



NB Short pulsed high peak-power lasers are particularly hazardous to the eye, particularly at wavelengths that reach the retina, as they deliver a lot of energy in a short period of time that can cause irreversible damage. Near infra-red lasers are also particularly hazardous because you can't see the beam but it could be focused on the retina and you would only be aware of it after damage has been caused.

Penetration of laser radiation into the skin



The skin can tolerate a great deal more exposure than the eye and less research has been done on damage mechanisms. In general all lasers can cause surface burns of the skin and with high-powered lasers there would be no warning of this occurring. Near infra-red lasers are again of particular concern because they are more penetrating and can reach the subcutaneous layer.

Summary of biological effects associated with excessive exposure to optical radiation

Spectral Region	Eye	Skin
UV-C (180-280nm)	Photokeratitis	Erythema (sunburn) Accelerated skin ageing increased Increased pigmentation
UV-B (280-315nm)		
UV-A (315-400nm)	Photochemical cataract	Pigment darkening Photosensitive reactions
Visible (400-780nm)	Photochemical and thermal retinal injury	
IR-A (780-1400nm)	Cataract, retinal burn	Skin burn
IR-B (1.4µm- 3.0µm)	Aqueous flare, cataract, corneal burn	
IR-C (3.0µm- 1mm)	Corneal burn only	

More detailed information on biological effects can be found on pg83 of BS-EN 60825-1:2007. This is also repeated as Annex C to PD IEC TR 60825-14:2004.

APPENDIX 16 – EXAMPLES OF LASER ACCIDENTS

1. Accident at a Midlands University in the UK in 1999

Late one afternoon a postgraduate student was aligning two lasers at different wavelengths that had been set up in a relatively new configuration. The beam from a dye laser (720nm, 10 mJ, 10 ns pulse at 10 Hz) was passed through a dichroic mirror coated for high reflection at 266 nm in order to combine it with the beam from a fourth harmonic Nd:YAG laser (266 nm, 50 mJ, 10 ns pulse at 10 Hz). This configuration resulted in a partial reflection from the rear of this mirror (approximately 5% of the dye laser) in an upward direction.

Temporarily forgetting the presence of the stray beam, the person leaning over the top of the apparatus received a single pulse of light from the dye laser reflection. This immediately left a large blind spot in the person's central vision in one eye. The person was not wearing protective eyewear as it was claimed they could not see that the beams they were aligning were coincident (*but both were at invisible wavelengths so they could only see the fluorescence*). The experiment was shut down and the user was accompanied to the local hospital Eye Unit. On examination the person was informed that there was a small burn on the fovea and that he would be referred to a consultant as a matter of urgency.

As to the absence of beam enclosures (drainpipes had been used previously), because of the orientation of the experiment being changed these had not been re-incorporated at this stage. The source of the reflection had allegedly been identified prior to the injury and this had been listed as an action to do by the injured person. There was some concern with regard to the examination and advice received from the local hospital Eye Unit. It was concluded that the most appropriate action was to get the injured person to the Moorfields Eye Hospital, Accident and Emergency Unit as soon as possible (the afternoon after the incident) to obtain a second examination. It was confirmed that the fovea had been damaged leading to a blind spot and peripheral blurring in the left eye. As a consequence the following may be of use to others:

a) Risk assessments need to be scrutinised, monitored and audited so that it can be shown that they are suitable and sufficient. Essentially three elements related to the optical hazard need to be covered (i.e. initial set up/alignment, normal operation/tweaking and the introduction of new components) and protocols detailing precautions need to be in place. Appropriate justification of procedures outside of conventional guidance need to be documented. Associated hazards need to be dealt with also.

b) The importance of following procedures, such as eliminating stray beams/reflections and enclosing exposed beams as far as reasonably practicable needs to be strongly re-emphasised. Human factors need to be taken into account especially where there may be hazardous open beam work; in this case an eagerness to get results may have been a contributory factor.

c) Procedures in the event of an injury or suspected injury need to be in place and effective. In most laser eye injuries there is not a lot that can be done to rectify damage; it is essential that competent examinations are carried out as soon as possible and within 24 hours of the injury. Referral to Moorfields Eye Hospital in London should be made in the event of a serious laser eye injury. Thus in light of the number of injuries recently in the UK research institutions, emergency procedures in place need to be checked as to whether they are appropriate (all Class 3B/Class 4 laser users and their supervisors need to be aware of what to do).

2. Accident at Los Alamos National Laboratory, California USA, 2004

On 14th July 2004 an undergraduate student was injured whilst working with a Nd:YAG laser in the Chemistry Division. The work involved the use of two lasers one to analyse particles (L1) and one to generate and suspend particles in a target chamber (L2). On the day in question the Principle Investigator (PI) was using L1 in flash-lamp mode to illuminate the suspended particles. After firing and shutting down L2 the PI removed the beam stop from behind the target chamber and looked inside whilst L1's flash lamps continued to operate. When the student bent down to look too she immediately saw a flash and a reddish-brown spot in her left eye - a hole had been burnt in her retina.

An investigation followed and PI claimed that he was operating L1 with the Q-switched trigger cable disconnected from the pulse generator, however the investigating team confirmed that the laser could not lase under those conditions.

The accident investigation team found the following failures of management and procedures:-

- Neither the PI nor the student were wearing laser eye protection and there were no engineered safety measures in place.
- The PI did not recheck beam alignment or laser condition or check for beam reflections on July 13 or 14.
- The PI prepared an insufficiently detailed risk assessment/scheme of work and had not updated it to reflect experimental changes.
- The student had not received proper pre-job training and had been asked to sign up to the scheme of work after the accident.
- Responsible line managers had not monitored PIs safety practices
- The Line Manager and Laser Safety Officer had signed off PIs risk assessment/scheme of work without noting the lack of detail.
- Management did not ensure that PI followed the Local Rules
- No PI training in relation to mentoring students

As a result of this incident the Los Alamos Lab was required to review its procedures, improve safety management and improve training of mentors and students to ensure that this type of incident would hopefully not occur again.

Four top scientists faced disciplinary action after the accident and the Principal Investigator was sacked.

Both these accidents have similarities. In neither case was safety eyewear being worn. In both cases 2 lasers were being used and the individual was struck in the eye with a pulse from a pulsed laser that they were not expecting. If you are viewing an experimental set-up either:

- *a proper shutdown procedure must be followed before looking down beam-paths without safety eyewear, or*
- *safety eyewear must be worn, or*
- *viewing should be via a video camera in a safe location.*

APPENDIX 17 - USEFUL LINKS

Information sources

Further information on laser safety can be found from accessing the Health Protection Agency (HPA) website at:-

http://www.hpa.org.uk/laser/index.htm

HPA/NRPB have published guidance on the purchase and use of laser pointers:-

http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/InformationSheets/info_LaserPointers/

The International Commission on Non-Ionising Radiation Protection (ICNRP) has a useful bibliography of recent publications on optical safety many of which can be freely downloaded.

http://www.icnirp.org/pubOptical.htm

If it is intended to use lasers outdoors one must consult the Civil Aviation Authority (CAA) guidelines:-

http://www.caa.co.uk/docs/33/CAP736.PDF

Laser Safety Equipment and Software

BFiOptilas market a range of lasers, power meters, optical components, laser safety eyewear, laser guards etc and also offer an advice service. Information on their products can be found at:-

http://www.bfioptilas.com/

Lasermet sell an extensive range of laser safety products and laser safety software. They also offer a design and safety consultancy service and were founded by one of the leading laser experts in the UK - Prof Brian Tozer. A lot of useful information can be found on their site at:-

http://www.lasermet.com/

Laser Physics UK market a range of laser safety eyewear, power meters, optical components, safety barriers, curtains and blinds and laser safety software. Details can be found at:-

http://www.laserphysicsuk.com