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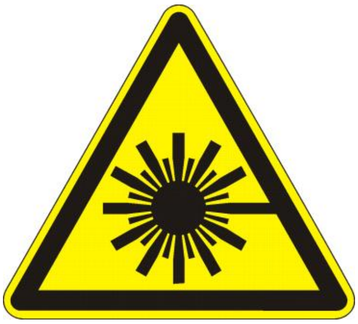
Association of University Radiation Protection Officers

GUIDANCE ON THE SAFE USE OF LASERS IN EDUCATION AND RESEARCH



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FOREWORD

This document represents general guidance on good practice. It is intended to aid in the identification of the hazards associated with work with lasers, to assist in assessing the risk and to outline appropriate control measures in an education and research environment. The guidance is not mandatory and each Institution is responsible for detailing their own management structures and arrangements, appropriate to local circumstances.

The Control of Artificial Optical Radiation at Work Regulations 2010 (AOR) aims to protect workers from the risks to health from hazardous sources of artificial optical radiation (AOR) including lasers. The Regulations include the requirement to assess and control the hazards from light emitted from all artificial sources in all its forms such as ultraviolet, infrared and laser beams.

This guidance draws from, and should be used together with, the applicable British Standards document(s) in the BS EN 60825 series of documents (especially BS EN 60825-1 *Safety of laser products, Part 1: Equipment classification and requirements* and PD IEC/TR 60825-14 *Safety of laser products, Part 14: A user's guide)* and associated amendments. This revision, which replaces the 2012 version, has been produced following a review of the guidance available and changes made to statutory requirements. NB - the document does not provide detailed guidance on all aspects of the use of lasers and the advice and assistance of a Laser Protection/Safety Adviser should be sought for work with high-powered lasers.

In the past, work with open beams was common place but now there is a shift in emphasis away from old cultures and practices; there is a strong emphasis on enclosing the optical hazard and thus avoiding the need for protective eyewear and door interlocks. Open beam work should now be the exception and only after a robust justification has been made that it is not reasonably practicable to enclose the beam.

It is intended to review and update this document on a regular basis and to publish it on the AURPO web site at:-

https://aurpo.org.uk/

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CONTENTS

1. INTRODUCTION

The word **laser** is an acronym for Light Amplification by the Stimulated Emission of Radiation. The 'light' produced by a laser, a form of non-ionising optical radiation, has a unique combination of spatial coherence (all the waves are in phase); monochromaticity (i.e. have just one colour or a narrow bandwidth) and usually high collimation (i.e. low angular divergence such that the beam does not 'spread out' significantly with distance). This combination of characteristics distinguishes laser radiation from all other light sources.

Lasers come in various shapes and forms. They have many uses in teaching, research, manufacturing, medicine, dentistry, shop checkouts and most commonly at work in the office. Lasers emit radiation as narrow concentrated beams of light, not necessarily visible to the human eye. The optical and skin hazards presented by lasers vary markedly according to the wavelength and power of the output. The hazards of lasers are often associated with the ability of the laser beam to damage eyesight or burn skin, but quite often the radiation or optical hazards are not the ones that present the greatest risk, with associated risks from electrical supplies, cryogenic liquids or chemical dyes being more hazardous.

There is a legal requirement to identify risks and take appropriate action to eliminate or control those risks (optical and non-optical). We all have a responsibility under the Health & Safety at Work etc. Act 1974 to ensure that work with lasers is carried out safely. Users have a duty to protect both themselves and others from the potential hazards involved, particularly when working with the more powerful lasers.

Within the EU, the Artificial Optical Radiation Directive was published in the Official Journal of the European Communities on 27 April 2006 (Ref: L114) under the title of "Directive 2006/25/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (artificial optical radiation)". Laser optical radiation is dealt with in Annex II of the Directive and Institutions should have access to this as a reference. Within the UK, the Control of Artificial Optical Radiation at Work Regulations 2010 (AOR) came into force with the aim to protect workers from the risks to health from hazardous sources of artificial optical radiation (AOR) including lasers. The Regulations include the requirement to assess and control the hazards from light emitted from all artificial sources in all its forms such as ultraviolet, infrared and laser beams. Guidance for Employers on the Control of Artificial Optical Radiation at Work Regulations (AOR) 2010 has been produced by the Health & Safety Executive (HSE). In addition, the European Commission's publication A non-binding guide to the Artificial Optical Radiation Directive 2006/25/EC covers applications posing minimal risk and provides guidance on others. An assessment methodology is set out and the guide outlines measures to reduce hazards and check for adverse health effects.

The assessment of non-optical hazards is dealt with by a number of different regulations which may be appropriate; for example, the Workplace (Health, Safety and Welfare) Regulations 1992, the Electricity at Work Regulations 1989 and the Control of Substances Hazardous to Health Regulations 2002.

The safety of laser products is covered by the BS EN 60825 series of documents. The base standard, BS EN 60825-1 *Safety of laser products, Part 1: Equipment classification and requirements*, is a `euro norm' based upon the corresponding International

Electrotechnical Commission's IEC 60825 documents. The 60825 series encompasses a range of standards for manufacturers of lasers, fibre optic systems, laser guards and free-space communications systems etc. Of particular importance for users is the Technical Report PD IEC/TR 60825-14 *Safety of laser products, Part 14: A user's guide* which is a detailed user's guide that incorporates a risk assessment approach to laser safety.

Many Institutions have internet access to British Standards Online and have licence subscriptions allowing standards to be downloaded. Each should at least have access to the latest Technical Report PD IEC/TR 60825-14.

The previous classification system, a system of seven classes (1, 1M, 2, 2M, 3R, 3B & 4), has had an additional laser safety class added, i.e., Class 1C.

Other changes in the updated and restructured BS EN 60825-1:2014 Edition 3 includes:

- the removal of measurement condition 2 ("eye loupe" condition);
- a classification of the emission of laser products below a certain radiance level that are intended to be used as replacement for conventional light sources which can, as an option, be based on the IEC 62471 series;
- updated accessible emission limits (AELs) for Class 1, 1M, 2, 2M and 3R of pulsed sources, particularly of pulsed extended sources, to reflect the latest revision of the ICNIRP guidelines on exposure limits (www.icnirp.org); and
- modified wording to explanatory labels in addition to alternative labels.

Whilst accessible emission limits (AELs) for Class 1, 1M, 2, 2M and 3R of pulsed sources, particularly of pulsed extended sources, to reflect the latest revision of the ICNIRP guidelines on exposure limits have been changed in the laser standard this change has not been mirrored in an update to the Directive 2006/25/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (artificial optical radiation).

2. LASER SAFETY POLICY and ADMINISTRATIVE ARRANGEMENTS

Each Institution should establish policy and administrative arrangements/procedures for laser safety. This should also cover the purchase, leasing or loan of new or re-furbished lasers and their acceptance to ensure that lasers have been classified correctly, labelled correctly and are safe to operate.

Instilling a safety culture within research is of great importance. Where there is a strong safety culture, those at various levels including research workers will develop the necessary skills to recognise hazards, to assess the risk and minimise the risk of exposures to those hazards. In 2015, a practical matter article was published in the Journal of Radiological Protection, Volume 35, Number 4, entitled "The advantages of creating a positive radiation safety culture in the higher education and research sectors". Poor radiation protection culture and poor educational and research quality have a strong positive correlation and if establishments want to excel then sub-standard safety attitudes have no place.

HSE has moved away from using the POPMAR (Policy, Organising, Planning, Measuring performance, Auditing and Review) model of managing health and safety to a 'Plan, Do, Check, Act' approach. The move towards Plan, Do, Check, Act achieves a balance between the systems and behavioural aspects of management. It also treats health and safety management as an integral part of good management generally, rather than as a stand-alone system. This approach is covered in the HSE Guidance HSG65 Managing for Health and Safety.

In the past, work with open beams was common place but now there is a shift in emphasis away from old cultures and practices; there is a statutory requirement to minimise the risk. The most effective control measure is by enclosing the optical hazard and thus avoiding the need for protective eyewear and door interlocks. Open beam work should now be the exception and only after a robust justification has been made that it is not reasonably practicable to enclose the beam. Regulation 4 of the Artificial Optical Radiations Regulations has a specific duty for an employer to ensure that any risk of adverse health effects to the eyes or skin of employees as a result of exposure to artificial optical radiation which is identified in the risk assessment is eliminated or, where this is not reasonably practicable, reduced to as low a level as is reasonably practicable. In most situations it is considered reasonably practicable to enclose the beam or restrict access through engineering controls.

This guide does not imply that it is acceptable to have accessible beams, goggles and door interlocks in the absence of finding an appropriate engineering solution enclosing the hazard in the first instance. Restriction of access may be useful for other reasons such as to stop unauthorised persons interfering with the experiment. Any open beam work will therefore require very a robust justification

The lowest power laser suitable for the purpose should be used and lasers should be operated so that individuals are not exposed to levels in excess of the exposure limit values specified in the Regulations. In some cases appropriate measurements using specific detectors/instrumentation may be necessary; if this is the case then a suitably qualified person will be required to undertake the measurements. Written procedures for the safe operation of lasers should be drawn up and applied. Where practicable, all laser products should be Class 1 in normal use.

Each Institution should have their own local arrangements and management structure defined with the Vice-Chancellor or Principal or Chief Executive, as appropriate, having overall responsibility for ensuring the effective management of all health and safety matters including laser safety.

Primary responsibility for research activities normally lies with the research supervisor/principal investigator.

All personnel involved in laser work have a role to play in ensuring the health and safety of themselves and others who may be affected by their work. Some key personnel have special responsibilities related to laser safety and these are described below.

A useful guide to the levels of competency required in laser safety is given in PD CLC/TR 50448:2005 *Guide to levels of competence required in laser safety*. This guide provides information and guidance to employers and employees using lasers. It outlines procedures for the management of laser safety and defines levels of competence for both those who have responsibilities for laser safety and those who work with laser equipment.

2.1 Laser Safety Adviser (LSA) /Laser Protection Adviser (LPA)/Laser Safety Officer (LSO)

The Institution will need the advice and assistance of a Laser Safety Adviser, LSA to manage work with lasers so as to comply with its statutory obligations especially when Class 3B and Class 4 lasers are being used. In doing this reference may be made to both this AURPO guidance and the BS EN 60825-14 user's guide.

Laser Protection Adviser, LPA in this context is the same as LSA. This role may be taken by the Radiation Protection Adviser/Officer, if suitably trained, or other competent person within the organisation, or assistance could be obtained as and when required from an external expert. Whatever the arrangements for expert advice the institution will need to appoint an overall in-house Laser Safety Officer, LSO to perform executive duties on behalf of the Vice-Chancellor to ensure that the institution procedures relating to laser safety are followed.

In particular, the LSO will need to ensure that arrangements are in place for:

- the training of new staff/students;
- identification of lasers and users of equipment;
- provision of a measuring service (where appropriate);
- inspection of all new laser facilities; and
- routine auditing of laser facilities.

2.2 Departmental Laser Safety Officers (DLSO)

In departments where Class 3B and Class 4 lasers are used the Head of Department in consultation with the Laser Safety Adviser/Officer should appoint a suitably qualified member of staff as Departmental Laser Safety Officer who will be responsible for ensuring that all lasers used in the department are identified and used in compliance with the Institution's Policy/Guidance on laser safety. A system should be in place so that the DLSO is aware of lasers being acquired, prior to them arriving on the premises, to ensure that adequate facilities are available for their safe use.

2.2.1 Duties of the Departmental Laser Safety Officer

A guide to the duties of a DLSO is given below. In some small Institutions these could well be looked on as the duties of the LSO as well. The DLSO should ensure that:-

- all lasers, except for low power Class 1 devices and Class 2 laser pointers, (whose classification has been verified by measurement rather than by label) are identified;
- any Class 1 product with an embedded Class 3B or Class 4, apart from "consumer type" Class 1 products, should be identified;
- all lasers are labelled in accordance with Appendix 10 and laser designated areas clearly identified;
- schemes of work are drawn up, where necessary, for the safe operation of lasers (see example in Appendix 5) including any robust justifications why it is not reasonably practicable to enclose any open beams. These will normally be required for all Class 3B and Class 4 lasers especially when not totally enclosed;
- personnel intending to work with Class 3R, Class 3B and Class 4 lasers, and others who may be working with modified Class 1M or Class 2M devices, will need to be identified and receive training in the safe use of lasers;

- ensure arrangements are in place for laser safety eyewear to be provided and worn (when appropriate and instructed) by all people working with Class 3B and Class 4 lasers when the beam is not totally enclosed and that training is given in the use and maintenance of this eyewear;
- undergraduates working with lasers should use the minimum power laser practicable and follow a written scheme of work;
- all lasers in the department are used in accordance with the institution's arrangements; and
- routine surveys are undertaken to ensure compliance with the risk assessment and control measures determined.

Some parts of EN BS 60825-1 are normative for manufacturers i.e., these are required to claim conformity with the standard, which has implications for claiming compliance with the essential requirements of product directives. As an aid for surveys, a summary of the requirements placed on manufacturers and guidance to users derived from BS EN 60825 is given in Appendix 7. More detailed information can be obtained by referring to the standards directly.

If a survey reveals non-compliance such that the risks have not been reduced to as low a level as reasonably practicable by an appropriate control measure and a potentially dangerous situation exists, the laser should not be used until the situation has been remedied by the adoption of additional control measures.

2.3 Responsibilities of Research Supervisor/Principal Investigator

The day-to-day health and safety management of individual research projects is normally the responsibility of the research supervisor/principal investigator. It is appropriate that they have the responsibility for ensuring any laser equipment bought in is fit for purpose and safe to use.

The Research Supervisor/Principal Investigator should ensure that:-

- the LSO is informed of the intention to buy a laser system or bring one on site prior to its purchase or loan and arrival;
- all work involving hazardous lasers must be covered by risk assessments and where appropriate by written schemes of work and protocols;.
- there should also be procedures to ensure that lasers are made safe prior to disposal and dealt with appropriately if they contain hazardous materials;
- their laser workers are effectively trained in the operating techniques required; and
- inexperienced staff are adequately supervised.

2.4 Responsibilities of Laser Users

Laser users also have responsibilities:-

- to observe the Policy/Guidance and Schemes of Work applicable to the lasers that will be used and to follow the guidance of supervisors and the Departmental Laser Safety Officer;
- not to leave a laser experiment running unattended unless a risk assessment has established that it is safe to do so;

- for their own safety and that of others who may be affected by their acts or omissions; and
- when working with Class 3B or Class 4 lasers there is the possibility of stray laser beams that could damage the eyesight; where required and provided for use, the appropriate laser eyewear **MUST BE WORN** as instructed.

3. HAZARD CLASSIFICATION FOR LASERS

Lasers produce electromagnetic radiation at wavelengths extending from 100 nm in the ultra-violet, through the visible (400 - 700 nm), and the near infrared (700 - 1400 nm), to the far infrared (1400 nm - 1 mm). Thus, the optical radiation emitted can be either visible or invisible. Lasers can be operated in a number of different modes. Some lasers produce a continuous output and are known as continuous wave or CW lasers. The power outputs of CW lasers are usually expressed in terms of watts (W). Others operate in a pulsed mode producing short bursts of radiation. The power of the laser output can vary from less than 1 mW to many watts in some CW devices. The energy output of pulsed lasers is generally expressed in joules (J) per pulse.

Because of the wide ranges possible for the wavelength, energy content and pulse characteristics of laser beams, the hazards arising from their use varies widely. It is impossible to regard lasers as a single group to which common safety limits can apply. A system of laser classification is used to indicate the level of laser beam hazard as it emerges from the laser product and maximum Accessible Emission Levels (AELs) have been determined for each class of laser. The previous classification system, which was based on a system of seven classes (1, 1M, 2, 2M, 3R, 3B & 4), now consists of eight classes (1, 1M, 1C, 2, 2M, 3R, 3B & 4) and these are described below.

3.1 Class 1

Lasers that are safe under reasonably foreseeable conditions of operation, either because of the low emission of the laser itself, or because of its engineering design such that it is totally enclosed and human access to higher levels is not possible under normal operation. A laser that emits laser radiation below the Class 1 AEL under all conditions of operation and failure is exempt from most of the requirements of the standard.

NB If access panels of a totally enclosed system are removed for servicing etc. then the laser product is no longer Class 1 and the precautions applicable to the embedded laser must be applied until the panels are replaced. It is important that when such systems are installed in open laboratories, the potential for this should be considered prior to first installing the system.

3.2 Class 1M

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

a) With a diverging beam if optics are placed within 100 mm of the source to concentrate/collimate the beam (this condition only applies to communication lasers).

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

3.3 Class 1C

Any laser product which is designed explicitly for contact application to the skin or tissue and that:

- during operation ocular hazard is prevented by engineering means, i.e. the accessible emission is stopped or reduced to below the AEL of Class 1 when the laser/applicator is removed from contact with the skin or tissue,
- during operation and when in contact with skin or non-ocular tissue, irradiance or radiant exposure levels may exceed the skin MPE as necessary for the intended treatment procedure, and
- the laser product complies with applicable vertical (product-specific) standards

3.4 Class 2

Lasers that only emit visible radiation in the wavelength range from 400 nm to 700 nm and whose output is less than the Class 2 AEL. They are safe for accidental viewing as eye protection is afforded by aversion responses, including the blink reflex. This reaction may be expected to provide adequate protection under reasonably foreseeable conditions of operation including the use of optical instruments for intrabeam viewing.

3.5 Class 2M

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

a) With a diverging beam if optics are placed within 100 mm of the source to concentrate/collimate the beam (this condition only applies to communication lasers).
b) With a large diameter collimated beam viewed with binoculars or a telescope.

3.6 Class 3R

Lasers that emit in the wavelength range from 180 nm to 1 mm where direct intrabeam viewing is potentially hazardous but the risk is lower than for Class 3B lasers, and fewer manufacturing requirements and control measures for the user apply. The AEL is restricted to no more than five times the AEL of Class 2 for visible wavelengths and no more than five times the AEL of Class 1 for other wavelengths.

3.7 Class 3B

Lasers that are normally hazardous when direct intrabeam exposure occurs (i.e. within the Nominal Ocular Hazard Distance (NOHD), which is the distance within which the beam irradiance or radiant exposure will exceed the appropriate MPE). Viewing diffuse reflections is normally safe. Output levels must be less than the appropriate AELs for Class 3B devices.

3.8 Class 4

High power lasers that exceed the AELs for Class 3B products that are also capable of producing hazardous diffuse reflections. They may cause skin injuries, could also constitute a fire hazard and could cause hazardous fumes to be produced as well as being a hazard to the eyes. **Their use requires extreme caution.**

3.9 Example AELs

The AELs for He-Ne lasers emitting a narrow beam in CW mode at 633nm are as follows:-

- Class 1 and 1M 0.39 mW
- Class 2 and 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 - 700 nm except for Class 1 and 1M devices where there are further restrictions for wavelengths <500 nm. See BS EN 60825-1 for full details.

***NB** Maximum output from Class 1M and Class 2M devices can take them well into Class 3B if the output is collimated.*

3.10 Maximum Permissible Exposures

The main criterion, within BS EN 60825, for assessing the optical safety of a given situation is the maximum permissible exposure (MPE). The MPE is that level of laser radiation to which, under normal circumstances, persons may be exposed without suffering adverse effects. The MPE levels represent the maximum level to which eye or skin can be exposed without consequential injury immediately or after a long time and are related to the wavelength of the radiation, the pulse duration or exposure time, tissue at risk and, for visible and near infra-red radiation in the range 400 nm to 1400 nm, the size of the retinal image. MPE levels are specified in Tables A.1 to A.5 in BS EN 60825-1:2014 *Safety of laser products Part 1: Equipment classification and requirements*.

Planned ocular exposure to laser radiation should not exceed the MPE for the intended exposure duration. However, for visible laser beams, sub-damage threshold effects, such as distraction, dazzle, glare and afterimages, also should be considered. Example of the calculation of MPEs and Nominal Ocular Hazard Distance, NOHD are given in PD IEC/TR 60825-14. Software packages are available that can be used to assess the hazards of a given situation; these packages can be used to calculate the MPE and the (NOHD). However, a word of caution, the output of these expert systems is only as good as the detail and accuracy of the data input and users still need to have a good understanding of the BS requirements.

3.11 Exposure Limit Values

Any assessment of the optical radiation hazard as set out in the Artificial Optical Regulations must include consideration of the level, wavelength and duration of exposure and the Exposure Limit Values (ELV). For laser radiation, the exposure limit values are those values set out in Annex II of Directive 2006/25/EC of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation). Adherence to the exposure limit values should provide a high level of protection as regards the health effects that may result from exposure to optical radiation.

So where in the past calculations concentrated on Maximum Permissible Exposures (MPE) and Accessible Exposure Levels (AEL), current legislation requires assessment against Exposure Limit Values (ELV).

Cautionary note: Most of the ICNIRP changes to the MPEs have resulted in relaxations, so if the latest MPEs are used in many situations there may a conflict with the statutory accepted exposure limits values and hence a statutory breach. Thus it is important to use exposure limit values. It would only be advisable to follow the new MPE values only where they are more restrictive than the Exposure Limit Values.

4. GENERAL SAFETY PROCEDURES

4.1 Identification of Lasers/ Laser Inventory

As a general rule, all Class 1 products with embedded Class 3B and Class 4 lasers, where servicing requires operation of the laser under Class 3B or Class 4 conditions, Class 3R, 3B and Class 4 devices should be identified and a laser inventory for each department maintained; see example inventory proforma in Appendix 1. There may be occasions when this is not practicable because the laser products are in fact just electrical components. In circumstances like this it should be the use of particular types of laser device that should be recorded. It may be useful to also note the use of Class 1M, Class 2M and Class 2 products but it is not necessary to record the use of low powered Class 1 devices, Class 2 laser pointers or the use of embedded lasers in products such as DVD players and laser printers; the exception as above will be products with embedded Class 3B and Class 4 lasers, where servicing requires operation of the laser under Class 3B or Class 4 conditions. The LSO should keep a copy of each departmental list. Departments will maintain these lists and notify the LSO of changes. Before the operation of any new laser or significant modifications the LSO should be consulted.

As a cautionary note many pieces of research equipment used within biomedical sciences, science and engineering may contain lasers. It is only when the engineer turns up for servicing that users discover they have a laser product. Where an item of research equipment is labelled with a laser warning symbol or label the appropriate DLSO or LSO should be notified.

4.2 Record/Registration of Users of Lasers

In order to make people aware of the hazards of lasers and to ensure that safe systems of work are being practiced, management arrangements should be in place to identify users of lasers. Risk assessments should also identify users of lasers and a list/record must be kept up to date in departments. Institutions may choose, for operational reasons, to have some form of registration system; an example registration form is given in Appendix 2. 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 be identified. Persons who could or are going to modify Class 1M or 2M devices should also be identified, as they will require instruction/training.

4.3 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. 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.

An example of a training record form for authorised laser users is given in Appendix 13.

PD CLC/TR 50448:2005 *Guide to levels of competence required in laser safety* details that laser workers should be sufficiently competent in the operation and use of the equipment and should understand

- the general nature of laser radiation;
- the 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
- be familiar with the Institution's procedures and policy governing laser use, including emergency action and accident reporting procedures.

4.4 Undergraduate Work

If reasonably practicable, undergraduate work should be restricted to Class 1/1M, 2/2M or visible beam CW 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 and a written Scheme of Work 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 3B or Class 4 lasers should be treated as laser workers and be subject to the normal registration and training process. The risk assessment should take into account the inexperience of the users and additional close supervision is likely to be necessary.

4.5 Labelling of Lasers

Lasers that are safe within reasonable foreseeable conditions of operation in Class 1 do not need warning labels. Supplementary information describing the laser product as a 'Totally Enclosed System' with details of the embedded laser clearly displayed is required in situations where access to the embedded product is routinely required. 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 10.

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 our BS), they will need to be relabelled. Institutions should note that for mains powered equipment the labelling of lasers should comply with European Standards and any Institution obtaining a laser directly from the U.S. and elsewhere overseas will assume the responsibilities of the importer and supplier.

Laser products not being labelled correctly pose a product safety issue and raise the question of what else could be deficient in terms of compliance and safety. Where there are concerns over products that come in to establishments from suppliers with safety issues, then these should be referred to the supplier in the first instance. Where there is no response or resolution, then consideration should be given to reporting the issues to Health and Safety Executive Product Safety team.

4.6 Designation of Laser Areas

As referred to earlier, in the past, work with open beams was common place but now there is a shift in emphasis away from old cultures and practices; there is a statutory requirement to minimise the risk by enclosing the optical hazard where practicable and thus avoiding the need for protective eyewear and door interlocks. By default beams should be enclosed; open beam work needs to become the exception. Enclosing the beam hazard is the priority with regards to optical safety; however there may be situations where this is not reasonably practicable. Where this is the case and enclosing the hazard is not reasonably practicable there needs to be a robust justification as to why enclosing is not reasonable.

Access restriction can be useful for other reasons particularly to stop unauthorised persons interfering with experiments.

A “laser controlled area” is an area where the occupancy and activity of those within is subject to control and supervision for the purpose of protection from the laser radiation hazards. Access to a laser controlled area should be restricted to all except authorised persons when the laser is turned on and there is the possibility of exposure. Class 3B and 4 lasers should only be operated in a laser controlled area following a robust justification as to why enclosing is not reasonably practicable. If engineering controls have not entirely eliminated the risks, an interlock system should be fitted (or other means of protecting unauthorised people, e.g., by controlling access by swipe card or key access). Access control with a means of override for authorised users has associated risks and should never be the default situation; it must be the subject of a robust justification. For example, how does an authorised user know that it is safe to open the door if someone in the room is working with accessible laser beams? Any access control system (including interlocks) should be subject to a risk assessment to ensure that the risk to authorised users is adequately managed.

The points of access to areas in which Class 3B and Class 4 lasers are used must be marked with appropriate warning signs – see Appendix 10. There may also be experiments where open beam work with modified Class 1M/Class 2M or Class 3R lasers are used that will also warrant the display of appropriate warning signs.

4.7 Laboratory Design

The default for laser systems is that beams should be enclosed and where this is not the case there should be a robust justification as to why this is not reasonably practicable together with a full risk assessment. Where the beam cannot be effectively enclosed then the following need to be considered.

The following considerations relate mainly to the use of Class 4 lasers but some may be appropriate for Class 3B devices as well, or as general specifications for a laser laboratory.

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 and may need to be covered or protected by suitable blinds. These should be non-reflective and may need to be fireproof where higher-powered 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 if reasonably practicable;
- 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; and
- provide sufficient and adequate power supplies for all ancillary equipment and apparatus so that the use of trailing leads is minimised.

4.8 Experimental set-up

Before starting the use of any laser there are a number of basic risk reduction measures that should be considered:

- Can work be carried out in a total enclosure?
- Can a lower powered laser be used?
- Can the output power of the laser be restricted if full power is not needed?
- Can intra-beam viewing be prevented by engineering design?
- Can the laser be used in a screened off area - limiting potential for others to be affected?
- Beam paths should be kept below eye height for the user, as short as possible, optical reflections should be minimised and the beam terminated with an energy absorbing non-reflective beam stop.
- The laser and optical components should be securely fixed to the bench 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

<1 mW (Note: 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, wristwatches etc.
- And don't forget to have the laser pointing away from the laboratory entrance!

5. Engineering Controls

5.1 Access prevention

The use of barriers and enclosures is an effective way of reducing exposure. By default beams should be enclosed; open beam work needs to become the exception. 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. Laser guards are covered in more detail in BS EN 60825-4:2006+A2:2011 *Safety of laser products. Laser guards*.

Any assessment of risks should include the likelihood of gaining access to the beam. Tamper-proof screws or an interlocking device may be necessary.

Note: Interlocks should meet current interlocking standards – refer to BS EN ISO 14119 *Safety of machinery. Interlocking devices associated with guards. Principles for design and selection* as a starting point.

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

5.2 Viewing windows

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

5.3 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.

5.4 Interlocks

Within an institutional environment, access to buildings is normally restricted by use of card entry etc. However, there may be security issues, for example, where you need to consider the possibility of inadvertent or malicious entry to laser laboratories, and ensure that access is safe under all circumstances. Levels of security are variable throughout institutional buildings.

Note that the quality of an interlock is important where it is being relied on for safety. It must be failsafe under reasonably foreseeable single fault conditions and it must not be possible to override the interlock casually. Interlocks must be tested on installation and checked periodically.

5.4.1 Access Panel Interlocks

An access panel interlock is used to reduce the laser power to the appropriate ELV when the panel is opened, or keep the panel locked while the laser is turned on.

5.4.2 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).

5.4.3 Non-locking Interlock System

This is a commonly used system by which opening the door trips the interlock. Laser operation is interrupted. Their use is normally only justified when experiments are long-term and cannot be enclosed or where there are laser stability issues and again total enclosure is not possible.

The interlock system will then protect any untrained, unauthorised person entering the room. Any use of an interlock override greatly reduces the effectiveness of an interlock system. Overrides must be only be used with great care and only when there is no hazard such as when a secondary barrier is used between the system and door. An intercom may be placed outside the door for requesting entry.

5.4.4 Locking Interlock System

Using this system, the laser cannot be enabled while the laboratory door is open, and the door is held shut while the laser is in use. Use of a locking system raises other concerns for safety, so there must be emergency entry and exit. This requires failsafe “positive break” door locks or mag locks, a failsafe control system, emergency stop and/or door release, or a break glass either side of every door.

N.B. Non-positive break switches, such as micro switches, are not suitable for use in interlocks; failure of spring or contact weld will result in fail to danger. However, positive break switches, where contacts are forced open mechanically by opening the guard or door, means that the connection is failsafe.

5.4.5 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.

5.4.6 Methods of Interlocking

The power supply may be interlocked so that the laser is switched off when the interlock is tripped. Alternatively, in situations where interrupting the power supply may cause damage to the laser, or if the laser requires time to re-stabilise, an interlocked beam shutter may be used. The shutter should be gravity fed. All Class 3B and 4 lasers should have an interlock connector which can be connected to an interlock control system.

6. PRECAUTIONS FOR SPECIFIC CLASSES OF LASER

6.1 Class 1

Class 1 laser products/systems do not require any special precautions or formal control measures. The exception is where such a product consists of a totally enclosed Class 3B/4 laser system and access is required for the purpose of servicing or alignment. In this case, it should be included on the laser inventory and there should be a Scheme of Work for that activity.

6.2 Class 1M and 2M

Class 1M and 2M products can be hazardous if the output is viewed with optical instruments. Modification of these products needs to be carefully assessed, reclassification may be necessary and the appropriate control measures detailed.

6.3 Class 2

For Class 2 laser products, protection is based on exposure being limited by the natural aversion response (0.25 sec). Simple measures such as information to users not to deliberately aim the beam at people, stare into the beam and terminate the beam at the end of its useful path will be sufficient.

6.4 Class 3R

For Class 3R products, the control measures will include:

- terminating the beam at the end of its useful path;
- avoiding beam paths at eye level and where practicable enclose the beam;
- instruction and training to an appropriate level;
- taking care to prevent unintentional specular reflections;
- where non-visible wavelengths are used an emission indicator device is to be used to indicate the laser is energised.

6.5 Class 3B and 4

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

For Class 3B or 4 lasers, each laser laboratory or experiment, as appropriate, should have its own Laser Scheme of Work based upon the conclusions of a risk assessment.

The name of the local Laser Safety Officer and the permitted authorised users, the extent of any laser designated area and reference to specific protocols that are to be used should be included in the scheme of work. (See example schemes of work with planning procedure in Appendix 5).

All the above control measures indicated for Class 3R lasers should be used as well as remote interlocks, safety interlocks (where a risk assessment justifies this), key control, beam stop/shutter and the full list of user precautions detailed in Appendix 7. Areas need to be defined and warning signs used.

The Scheme of Work should be displayed in a prominent position or readily available within a laboratory folder.

A summary of warnings and protective control measures from BS EN 60825 for all classes of laser is given in Appendix 7.

7. HAZARD/RISK ASSESSMENT

Excessive exposure to laser radiation will result in biological damage. The main areas at risk are the eye and the skin. Visible and near infra-red lasers are a special hazard to the eye because the very properties necessary for the eye to be an effective transducer of light result in high radiant exposure being presented to highly pigmented tissues. The biological effect of irradiation of skin by lasers operating in the visible (400 nm to 700 nm) and infrared (greater than 700 nm) spectral regions may vary from a mild erythema to severe blisters. See Appendix 11 for further information. This topic is covered in depth in Annex C of PD IEC/TR 60825-14:2004. When carrying out a risk assessment for the optical hazard, it is important to know of the effects of laser radiation on biological tissue.

Special considerations apply to the use of lasers for medical and dental work, and lasers for display purposes. Such work must be very carefully planned and controlled and specialist guidance followed.

Before the appropriate controls can be selected and implemented, laser hazards must be identified and evaluated together with non-beam hazards that may be present. The laser's capability of injuring personnel and the environment and the way in which the laser or lasers are 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; and
- information provided by manufacturers in accordance with product directives.

7.1 Stages in a Risk Assessment

There are basically 5 stages to a risk assessment:

1. Identify the hazards, i.e. the potential for harm;
2. Assess risk from these hazards and who is at risk;
3. Determine and implement the necessary control measures;
4. Assess residual risk – repeating stage 3 if necessary; and
5. Record the findings.

To assist in identifying hazards and risk control measures, a proforma has been developed for Class 1M, 2/2M and 3R lasers (Appendix 3) and Class 3B & 4 laser systems (Appendix 4).

Class 3B and Class 4 lasers are capable of causing significant eye injury to anyone who looks directly into the beam or its specular reflections. Diffuse reflections of a high-power laser beam can also cause permanent eye damage. High-power laser beams can burn exposed skin, ignite flammable materials and heat materials releasing hazardous fumes, gases or debris. Equipment and optical apparatus required to produce and control laser energy may also introduce additional hazards associated with high voltage, high pressure, cryogenics, noise, other forms of radiation, flammable materials and toxic fluids. Each proposed experiment or operation involving a laser must be evaluated to determine the hazards involved and the appropriate safety measures and controls required.

7.2 Assessing Risk

The persons who may be at risk need to be identified. These may include cleaning, service personnel, other contractors, visitors and the public as well as trained operatives.

Risk can be assessed by using quantitative measures that combine the likelihood of occurrence with the severity of injury; however, in laser safety it is usually more important to eliminate the risk of injury by adopting appropriate control measures in all situations where there is the possibility of ELVs being exceeded.

7.3 Laser Controls – optical hazards

Enclosing a laser system appropriately should eliminate or minimise the optical risk. Where this is not the case and where total enclosure has been justified as not reasonably practicable, the simplest rule to follow to avoid eye injury is not to look directly into a laser beam or its specular reflection, regardless of the laser's power or classification or the laser eyewear being worn. An Exposure Limit Value (ELV), should be calculated for laser sources present in a laser system based on the radiated wavelength(s), output power(s) or energy(ies), and, if appropriate, the pulse duration and pulse repetition rate. ELVs apply to a specific combination of these parameters and will usually change if any of the parameters changes. Engineering and administrative controls should be used to keep exposures below the ELV whenever practicable. Skin protection and laser eyewear should be used only where engineering and administrative controls are impractical.

7.3.1 Laser alignment

Avoidance of open beam alignment will minimise the optical radiation risk. This could be accomplished by designing and enclosing the laser system. The use of remote viewing and motorised systems for adjustment and alignment purposes may well be appropriate.

About sixty percent of laser accidents in research settings occur during the alignment process involving open beam work. Laser alignment guidelines to help prevent accidents, where open beam has been justified and assessed, should include:

- The training and instruction of Class 3B/4 laser users.
- Restricted access, unauthorised personnel must be excluded from the room or area.
- Instructions to remove watches and reflective jewellery before any alignment activities begin.
- Reducing the beam power down below the ELV where this is practicable..
- The use of a He-Ne or CW diode alignment laser (Class 2M or below), when possible, for a preliminary alignment.
- Identifying individual responsibilities - the individual who moves or places an optical component on an optical table is responsible for identifying and terminating each and every stray beam coming from that component.
- Identifying when the beam is directed out of the horizontal plane.
- Checks on the stability and rigidity of all optical mounts, beam blocks and stray beam shields.
- Use of beam paths at a safe height, below eye level when standing or sitting and not at a level that tempts one to bend down and look at the beam.
- The need for good alignment techniques, i.e., remote viewing and aligning at low power and aligning one wavelength at a time where more than one wavelength is used.
- The wearing of laser protective eyewear when appropriate.

7.4 Control of Non-optical hazards

Many hazards (other than from laser radiation) that can be found in the laser area must be adequately assessed and the risks controlled. The manufacturer's safety guidance material should help in identifying most of the associated hazards. The main non-optical hazards include:-

- **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;

- **fume** – 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 (>35 mW) 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; and
- **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, i.e., 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. Issues such as cleaners or maintenance staff inadvertently disturbing equipment or unsupervised access must also be addressed.

7.5 Laser accidents

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.

7.6 Assessing residual risk and recording the results

In most circumstances after introducing control measures one should be able to assess the residual risk as being low. One then needs to produce written Systems of Work and make it available to all users so that they are aware of all protective measures they should be taking and the procedures they should be following. See the example risk assessment in Appendix 4.

It should be noted that with the changing nature of experimental work it is important that the risk assessment and operating procedures are routinely reviewed and, most importantly, reviewed prior to any significant change.

8. PERSONAL PROTECTION

Total beam enclosure combined, where necessary, with the use of remote viewing systems should always be considered first as an alternative to reliance on personal protection.

Whenever there is a risk of laser exposure to levels above the specified ELVs, personal eye-protection is one of the commonest and important elements of personal laser protection. Personal eye-protection should be regarded as a last line of defence against exposure to laser radiation; it can be adopted only after a full safety evaluation has been carried out and other means of affording protection have been considered and rejected. Its use should not be regarded as a convenient alternative to proper engineering controls or thorough hazard assessments.

Requirements apply within Europe covering the specification, marking and testing of laser eye-protection, using protective effect rather than optical density. Scale numbers which take into account maximum spectral transmittance and resistance to laser radiation are used. These are detailed in BS EN 207: 2017 *Personal eye-protection equipment - Filters and eye-protectors against laser radiation (laser eye-protectors)* and BS EN 208: 2009 *Personal eye-protection – Eye-protectors for adjustment work on lasers and laser systems (laser adjustment eye-protectors)*. Annex B of both BS EN 207 and BS EN 208 provide the methodology for the selection of personal eye-protection depending on the type of laser radiation and the operating conditions.

When choosing personal eye-protection, it is important to consider not only the ability of the eyewear to attenuate the incident radiation but also to have a damage threshold high enough to withstand the maximum possible exposure long enough for avoiding action to be taken, and to take into account comfort and visual light transmission (mean percentage of visible spectrum that is not filtered by the eyewear). Special consideration needs to be made when selecting eyewear for femtosecond and picosecond pulsed lasers.

Information on specifying eye protection is given in PD IEC /TR 60825-14: *A user's guide*. Note: Whilst the user's guide contains some useful guidance it is intended for an international rather than a European or UK audience and explains the calculation of optical density (OD), which cannot be used for selection of eyewear in the UK.

Laser protective eyewear should never be relied on to provide protection against deliberate exposure to a laser beam but should be regarded as a means of providing some protection against accidental exposure.

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

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

When working with Class 4 lasers (and some Class 3B devices emitting in the UV) skin protection may also be required.

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

Personal protective equipment should be personal, i.e., it should be appropriately cleaned between users, or each user has their own. There are basic duties concerning the provision and use of personal protective equipment (PPE) and the requirements of the Personal Protective Equipment at Work Regulations 1992 (as amended).

9. MEDICAL SUPERVISION, EMERGENCY EYE EXAMINATIONS and ACCIDENTAL EXPOSURES

Eye examinations for laser users are not recommended as a part of a safety programme. The value of routine examinations for Class 3B/4 laser users has been reviewed and it is generally accepted that routine examinations are of little value and that the only reason for these may for medical legal reasons.

What is of more importance is having procedures in place if there has been an apparent or suspected ocular exposure. A medical examination by a qualified specialist needs to be carried out as soon as possible. In the event of an accident or incident involving suspected injury to the eye(s), an emergency examination should be carried out as soon as possible and within 24 hours.

The most appropriate Accident and Emergency Department that deals with eye injuries needs to be identified before the work is commenced. The injured party should be taken to this place. Suitable arrangements should be in place to ensure that all persons working with Class 3B/4 lasers are aware of the action to take in the event of an accident/incident. Each Class 3B/4 laser should have a card or *proforma* that can be taken with the casualty to Hospital. An example of such a card and the information that will be required in the event of an accident/incident is given in Appendix 9.

In the event of an eye injury caused by an individual staring down the beam of a lower powered laser the emergency arrangements for Class 3B/4 lasers should be followed.

Where an emergency eye examination is required, the Laser Safety Adviser and local Laser Safety Officer will carry out a detailed investigation of the accident/incident.

In the event of a skin injury, i.e. thermal burn, this can be treated as would any other burn.

All accidents and incidents, whether involving an emergency examination or not, must be reported promptly to the establishment’s Health and Safety Office using the appropriate current local Accident/Incident Report Form.

Depending on whether an injury has been sustained there may be a requirement to notify the Health and Safety Executive (HSE) under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 (RIDDOR). This will apply to staff at the establishment (workers) and non-workers (students). RIDDOR has slightly different requirements for injuries to workers and non-workers. Further guidance on RIDDOR is available on the HSE website.

There is **no** statutory requirement under the Control of Artificial Optical Radiation at Work Regulations 2010 (AOR) for medical surveillance for the eye. However, an appropriate medical examination is required if someone is exposed to laser radiation in excess of the Exposure Limit Value (ELV) in the Regulations.

10. LASER POINTERS

Small lasers are commonly available and some are used for presentation purposes as pointers. These laser pointers are normally classified at a level above Class 1 and therefore in some circumstances can cause harm, particularly by staring into the beam. In the past they were only available in red wavelengths and had output powers up to and sometimes over 5 mW. Nowadays devices are available emitting green wavelengths where the eye is more sensitive and lower powers are all that is needed so that laser pointers should now be Class 2 devices (output < 1 mW). Normally the eye's natural aversion response, including the blink reflex, affords protection to short duration accidental exposure.

Laser pointers should only be purchased from reputable suppliers and only be used for genuine purposes.

Laser pointers (or pens) used should be of Class 1 or Class 2; laser pointers of a class higher than Class 2 should not be used unless they have been measured and advice on their use has been sought from the LSO. The use of Class 3R laser pointers up to 5 mW may be justified for some applications in the workplace where the user has received adequate training.

Laser pointers are fairly easy to come by and some have been found, including counterfeit items, to emit much higher powers than stated or other wavelengths. Such devices are too powerful for general use as laser pointers and present an unacceptable risk of eye injury in normal reasonably foreseeable use – 150 incidents of eye injuries involving laser pointers since 2013 have been documented from use of excessive laser pointers. Any suspect laser pointers should be passed to the institution's LSO or similar for assessment.

Novelty lasers/laser pointers and "recreational" use of laser pens and pointers are not an acceptable use and should be strictly prohibited. Misuse of a laser pointer in such a manner that it could cause harm to anyone on or in the vicinity of the institution should be considered as gross misconduct and the appropriate penalty applied as prescribed by the institution.

Where genuine and appropriate laser pointers are used, instructions on their safe use should be readily available; Appendix 8 is an example of the instructions that should be provided.

11. CONSTRUCTION AND MODIFICATION OF LASER SYSTEMS

Anyone involved in designing, constructing and modifying laser systems must be familiar with the following requirements.

11.1 Supply of Machinery (Safety) Regulations

These regulations apply where the laser is, or is part of, a machine i.e., it has parts that are intended to move under an external power source. In addition, the regulations apply if the laser is subsequently made available for use by someone else as part of a commercial arrangement (which may be an issue in collaborations).

In most cases laser systems will be purchased and used unmodified. However in some cases systems will be modified or constructed, in these cases note has to be taken of legislation which covers the supply of machinery and/or the provision of work equipment.

With reference to 1.5 Risks due to other hazards, in the Supply of Machinery (Safety) Regulations 2008, there is a section on laser radiation (1.5.12) which requires:

Where laser equipment is used, the following should be taken into account:

- *laser equipment on machinery must be designed and constructed in such a way as to prevent any accidental radiation,*
- *laser equipment on machinery must be protected in such a way that effective radiation, radiation produced by reflection or diffusion and secondary radiation do not damage health,*
- *optical equipment for the observation or adjustment of laser equipment on machinery must be such that no health risk is created by laser radiation.*

The interpretation is that the above refers to laser equipment on machinery thus does not necessarily apply to all laser products just to those particular lasers associated with and on machinery.

11.2 Provision and Use of Work Equipment

With reference to the Provision and Use of Work Equipment Regulations 1998, Regulation 12, Protection against specified hazards:

(1) Every employer shall take measures to ensure that the exposure of a person using work equipment to any risk to his health or safety from any hazard specified in paragraph is either prevented, or, where that is not reasonably practicable, adequately controlled.

(2) The measures required by paragraph (1) shall—

(a) be measures other than the provision of personal protective equipment or of information, instruction, training and supervision, so far as is reasonably practicable; and

(b) include, where appropriate, measures to minimise the effects of the hazard as well as to reduce the likelihood of the hazard occurring.

11.3 Electrical Equipment (Safety) Regulations 2016

The Electrical Equipment (Safety) Regulations apply to all electrical equipment that is designed or adapted for use between 50 and 1,000 volts (in the case of alternating current) and 75 and 1,500 volts (in the case of direct current). The Regulations cover equipment that is intended for use in the workplace.

The regulations impose obligations on manufacturers and include ensuring that it has been designed and manufactured in accordance with the principal elements of the safety objectives set out in Schedule 1 to the Regulations.

11.4 Laser delivery systems via fibre

Optical fibres carrying laser radiation normally provide a complete enclosure of the optical radiation, and so prevent access to it. Where a fibre is disconnected or decoupled or a fibre break occurs then hazardous levels of laser exposure can be present.

12. CONTROLLING THE RADIATION SAFETY OF DISPLAY LASER INSTALLATIONS

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). The PLASA guidance document was introduced to replace *The radiation safety of lasers used for display purposes* - Health & Safety Executive publication HS(G)95 1996 ISBN 0 7176 0691 which has been withdrawn.

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 set out by the Institution.

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.

13. REFERENCES

Artificial Optical Radiation Directive, published in the Official Journal of the European Communities on 27 April 2006 (Ref: L114)
http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006L0025

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 communications systems*.

BS EN 60825-4:2006+A2:2011 *Safety of laser products. Laser guards*

BS EN 207: 2017*Personal eye-protection equipment - Filters and eye-protectors against laser radiation (laser eye-protectors)*

BS EN 208: 2009 *Personal eye-protection – Eye- protectors for adjustment work on lasers and laser systems (laser adjustment eye-protectors)*

BS ISO 3864-1:2011, *Graphical symbols. Safety colours and safety signs. Design principles for safety signs and safety markings*

BS EN ISO 14119:2013. *Safety of machinery. Interlocking devices associated with guards. Principles for design and selection*.

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http://www.plasa.org/technical/guidance/plasa_laser_guidance.pdf

RIDDOR - Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013
http://www.hse.gov.uk/riddor/

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The Control of Artificial Optical Radiation at Work Regulations 2010 (AOR)
http://www.legislation.gov.uk/uksi/2010/1140/contents/made

The Electrical Equipment (Safety) Regulations 2016
https://www.legislation.gov.uk/uksi/2016/1101/contents/made

The Provision and Use of Work Equipment Regulations 1998
http://www.legislation.gov.uk/uksi/1998/2306/made

The Supply of Machinery (Safety) Regulations 2008
http://www.legislation.gov.uk/uksi/2008/1597/pdfs/uksi_20081597_en.pdf

NB *Other useful web references are given in Appendix 12.*

Appendix 1 – Laser Inventory Proforma

LASER INVENTORY PROFORMA

Location	Manufacturer and Model	Type	Wavelength	Power Output (for CW) or Pulse Power, duration and repetition rate	Laser Class

Note: Do not include office based "consumer" Class 1 laser products.
See section 4.1 of the guidance.

Institution/Department: ………………………………………………………………….

Laser Safety Officer: …………………………………………………………………..

Date: ………………………………………………………………..

Appendix 2 – Registration Form for Laser Users

Name of Institution

REGISTRATION FORM FOR LASER USERS

Surname:		Sex:	
Prename(s):		Date of Birth:	
Title (Mr, Ms, Dr etc)		Status (Lecturer, RA, Technician, RS etc)	
email:		Supervisor:	
Department:			
Lasers to be used:			
Experiments to be performed:			
Labs to be used:			

Appendix 3 - Example Hazard & Risk Assessment

EXAMPLE - USE OF CLASS 1M, 2M and 3R LASERS
HAZARD & RISK ASSESSMENT

Location		**Assessment No.**	
Assessor		**Date:**	

Without the use of magnifying optics 1M devices do not pose an eye hazard, neither do 2M or Class 2 devices as long as you do not stare into the beam (eye protection is normally afforded by the aversion responses). An eye hazard is possible if there is: exposure in excess of more than 0.25 seconds from Class 2/2M lasers; exposure to Class 1M/2M; or if Class 3R lasers are viewed directly. Risk of eye injury is low. There is no skin or fire hazard.

1	**LOCATION AND VERY BRIEF DESCRIPTION OF THE WORK ACTIVITY**	

2 **LASER SPECIFICATION**

Model:	
Maximum Power	
Wavelength Range	

3	**OPTICAL HAZARD – Statement to explain why beam cannot be enclosed:**

4 **NON OPTICAL HAZARDS**

Detail the significant risks and the control measures necessary for any non-optical hazard identified and any optical hazard from 1M/2M Devices.	**Hazard/Risk**	**Control Measure**

5 **CONTROL MEASURES**

Avoid eye level beams and do not expose users or others to the beam.

N.B. Modified 1M/2M devices may need to be reassessed as a higher classified laser.

	**Follow the manufacturer's safety instructions. Take care when operating the laser system. Keep the laser 'on' only when necessary. Restrict unauthorised use. Terminate the beam at the end of its useful path.**
	**Do not point at or towards persons deliberately. Do not point at mirrored surfaces that may cause unplanned reflections. Never look into the laser aperture. Never look directly or stare into the beam/beam aperture when on. Never allow unauthorised use. Do not use optical viewing aids.**

5	**CONTACT**	NAME		PHONE	

Appendix 4 – Hazard and Risk Assessment – Class 3B and 4

USE OF CLASS 3B & 4 LASERS – HAZARD & RISK ASSESSMENT

Class 3B and Class 4 lasers are capable of causing eye injury to anyone who looks directly into the beam or its specular reflections. In addition, diffuse reflections of a high-power (Class 4) laser beam can produce permanent eye damage. High-power laser beams (Class 4) can burn exposed skin, ignite flammable materials, and heat materials that release hazardous fumes, gases, debris, or radiation. Equipment and optical apparatus required to produce and control laser energy may also introduce additional hazards associated with high voltage, high pressure, cryogenics, noise, and other forms of radiation, flammable materials, and toxic fluids. Thus, each proposed experiment or operation involving a laser must be evaluated to determine the hazards involved and the appropriate safety measures and controls required.

The 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.

School/Dept		**Assessment Number**	
Assessor		**Date of Assessment**	

1	**LOCATION OF THE WORK ACTIVITY**	

2 LASER IDENTIFICATION AND SPECIFICATIONS

Complete the following chart; list all lasers, including low power alignment lasers:

	Laser 1	**Laser 2**	**Laser 3**
Type:			
Manufacturer:			
Model:			
Serial #			
Maximum Power			
Maximum Pulse Energy			
Wavelength Range			
Wavelength Used			
Power Used			
Pulse Energy Used			
Pulse Length			
Pulse Repetition Rate			
Beam Diameters (x,y)			
Beam Shape (e.g. ellipse, box, circular)			
Beam Divergence (x,y)			
LASER CLASSIFICATION			

3	**DESCRIPTION OF ACTIVITY OR RESEARCH PROJECT** *Provide a brief description of the laser set up, its purpose and operational parameters.*	
	DURATION OF ACTIVITY/PROJECT *Is the work ongoing or for a limited period?*	

4	**IDENTIFICATION OF HAZARDS ADDITIONAL TO THE LASER HAZARD(S)**
	Electrical Hazards *Most lasers contain high-voltage power supplies and often large capacitors/capacitor banks that store lethal amounts of electrical energy.* **Are any special precautions/procedures required? Yes / No**
	Laser Dyes *Laser dyes are often toxic and/or carcinogenic chemicals dissolved in flammable solvents* **Are laser dyes used? Yes / No** Give details, if yes.
	Compressed and Toxic Gases *Hazardous gases may be used in laser applications, i.e., excimer lasers (fluorine, hydrogen chloride).* **Are compressed gases and/or toxic gases used? Yes / No** Give details, if yes.
	Cryogenic Fluids *Cryogenic fluids can create hazardous situations. Adequate ventilation must be provided.* **Are cryogenic fluids used? Yes / No** Give details, if yes.
	Fumes/Vapours/Laser Generated Air Contaminants from Beam / Target interaction *When laser beams are sufficiently energised to heat up a target, the target may vaporise, creating hazardous fumes or vapours that may need to be captured or exhausted.* **Is there a potential for fumes/vapours/Laser Generated Air Contaminants? Yes / No** Give details, if yes.
	UV and Visible Radiation/ Plasma Emissions *UV and visible radiation may be generated by laser discharge tubes, pump lamps or plasmas. The levels produced may be an eye and skin hazard.* **Is there a potential for significant UV/visible radiation? Yes / No**
	Explosion Hazards *High-pressure arc lamps, filament lamps, and capacitors may explode if they fail during operation. Laser targets and some optical components also may shatter if heat cannot be dissipated quickly enough.* **Is there an explosion hazard? Yes / No** Give details, if yes.
	Ionising Radiation (X-rays) *X-rays can be produced from two main sources, high voltage vacuum tubes of laser power supplies such as rectifiers, thyratrons, and electric discharge lasers. Any power supplies that require more than 15 kV may produce x-rays.* **Is there an ionising radiation hazard? Yes / No**
	Other hazards not identified above. Please specify

RISK ASSESSMENT and CONTROL MEASURES

5	**PERSONS WHO MAY BE AT RISK**	**Specified Authorised Laser Users** **Project Supervisors**

6	**OPTICAL HAZARD**	**Details of ELV/NOHD:**

7

MEASURES TO REDUCE LEVEL OF RISK (LASER HAZARD) **ANY OPEN BEAM WORK IS BY EXCEPTION AND MUST BE JUSTIFIED WITH AN EXPLANATION OF WHY BEAMS REMAIN ACCESSIBLE.**		
Are open or partially enclosed beams used during the following? This should include a statement why beams remain accessible for each.	1. Initial setting up and beam alignment; 2. Addition of new optical elements/lasers; 3. Day to day operation 4. Servicing	**YES / NO / n/a** **YES / NO / n/a** **YES / NO / n/a** **YES / NO / n/a**
Are there protocols/procedures to control risks from the ocular (and if applicable, skin) hazard?	1. Initial setting up and beam alignment; 2. Addition of new optical elements/lasers; 3. Day to day operation 4. Servicing	**YES / NO / n/a** **YES / NO / n/a** **YES / NO / n/a** **YES / NO / n/a**
List the operating protocols with references/dates/location. ALL OPEN BEAM WORK MUST HAVE AN APPROPRIATE PROTOCOL/OPERATING PROCEDURE		

8

INSTRUCTION/TRAINING Authorised laser users must receive appropriate training and instruction
Specify the instruction and training arrangements.
A list of authorised laser users is to be displayed

9	PERSONAL EYE-PROTECTION

Detail How Scale number was determined

Number available	Location	Manufacturer	Scale number	Emission type (D,I, R or M)	Wavelength

10	ASSESSMENT OF RISK (ASSOCIATED HAZARDS identified in Section 4 of this form)

	Hazard/Risk	Control Measure
Detail the significant risks and the control measures necessary (i.e. by reference to protocols/procedures or safety manual). For hazardous substances, specify the location of the appropriate COSHH assessments.		

11	MONITORING

Performance of control measures,

It is the individual responsibility of each laser operator to follow the guidelines on laser safety. Where control measures have failed or have been suspect then laser users should report these. Supervisors should monitor that users are complying with procedures as should the School and Institution Laser Safety Officers by carrying out periodic checks.

12	REVIEW

Enter the date or circumstances for review of assessment (3 years or the length of the particular project/worker if shorter.)

Where new lasers or components are introduced then these changes need to be assessed; protocols may need to be modified. A review would also be required where a new laser worker starts; ensure that they are informed of the relevant risks and protocols.

13	EMERGENCY ACTION

TO CONTROL HAZARDS — To stabilise situation e.g. turn off power source, etc.

Turn off power.

TO PROTECT PERSONNEL — Evacuation, protection for personnel, Special First Aid

Once power has been turned off the laser does not present an optical hazard to personnel area.

TO RENDER SITE OF EMERGENCY SAFE — POWER , VENTILATION

Turn off power.

14	EMERGENCY CONTACT	NAME		PHONE	

Appendix 5 – Example Scheme of Work

Example 1 - SCHEME OF WORK WITH PROCEDURE

Name of School/Dept: ……………………………………….
Laboratory/Room/Activity: ………………………………………..

These guidelines have been prepared by ....

Before commencing work with Class 3B/4 lasers, you must read this document, and sign the sheet at the end to confirm this, that you have understood the content and that you agree to abide by the protocols contained herein.

Purpose and Structure of this document

The principal aim of this document is to outline the elements of *good laser practice* as they apply specifically to experiments currently being undertaken in the above laboratory. General aspects of laser safety are covered in sections of the manuals accompanying the lasers.

The document is structured as follows: at the top level (this sheet) an overall description is made of laser research activity in this laboratory. The user is then referred to a number of accompanying documents under two headings: Laser types in use and Safety Protocols.

Description of Activity:

.... *Description of the activity/experiment and its purpose* ....

Four types of situation have been identified which require separate safety protocols, where appropriate:

- setting up;
- adding new elements to;
- day-to-day operation of the experiment ; and
- maintenance of the laser system.
- Servicing (usually carried out by a contactor)

Separate sections dealing with each of these are to be included where appropriate.

Lasers in use

.... *Reference to completed Hazard/Risk Assessment proforma* ....

As a general rule all Class 3B/4 laser emissions are capable of causing severe eye damage if viewed directly, or as a specular (i.e. mirror-like) reflection. Control measures (careful planning, beam pipes, blocking of reflections, safety eyewear) must be taken to avoid this!

Authorised users of the above lasers are (*to be named*):

Supervisor(s): ....
Student(s): ....
Postdoctoral fellow(s): ....
Other(s): ....

There should be reference to this guidance in particular the ***General Overview on Laser Hazard/Risk Assessment*** **and** ***Maximum Permissible Exposure Calculations.***

Laser safety protocol: Setting up

Definition

Setting up applies to the initial installation of a new experiment, and to major changes such as the addition of a new type of laser system, or, for example, a complete change of beam paths.

Protocol/Scheme of Work

Planning:

- Class 3B and 4 beams should be enclosed and any open beam work is by exception after being fully justified.
- The installation or changes should be discussed with a supervisor prior to operation of Class 3B/4 laser systems.
- In the case of a completely new experiment, the School Laser Safety Officer and/or the Institution Laser Safety Adviser must be consulted and invited to visit the lab.
- Open beam work is by exception and fully justified, after which the laser beam paths and associated optics should be planned to minimise the possibility of stray reflections.
- Termination of each main laser beam should be planned.
- Consideration should be made on how alignment is to be carried out. Where practicable, the use of cameras for viewing and remote adjustment should be promoted.
- Provision of suitable laser safety eyewear should be addressed at this stage.

Initial safety checks:

- Before starting the Class 3B/4 lasers, beam paths should be inspected for any objects that should not be there.
- Laser warning signs should be activated, where installed and unauthorised persons excluded and doors closed.
- Alignment may be carried out by one or at most two authorised laser operators. No one else may be present in the room during this procedure and watches, bracelets and other reflective jewellery should be removed.
- Appropriate personal eye-protection should be worn where required.

Initial alignment and suppression of stray reflections:

- Initial laser beam alignment should be performed with a Class 1 or 2 alignment laser (e.g., He-Ne or small CW diode laser). Remember that the final beam path may differ slightly due to dispersion (i.e., the beam path may be slightly wavelength-dependent)
- At this stage, each and every optic element in the beam path must be analysed for stray reflections. Initially this can be done by predicting the likely path of specular (i.e., non-diffuse) reflections and the actual reflections of the Class 1/2 alignment laser may also be used to help identify stray reflections.
- Suitable beam blocks, opaque at the appropriate wavelengths, must then be installed to block all these stray reflections.
- 'Beam pipes' or other suitable enclosures should be installed at this stage to cover longer runs of laser beam, and especially any beams that leave the confines of the laser table. It is recognised that there may be some places where beam pipes are

inappropriate, e.g. when the distance between optics is very short (in which case a beam tunnel may be more appropriate). Beam pipes should be designed to allow limited access to the beam for alignment checking without removal.

Alignment using Class 3B/4 lasers at low power

- The next stage of alignment using the Class 3B/4 lasers may be carried out only after obtaining the verbal permission of a supervisor.
- Alignment may be carried out by one or at most two authorised laser operators. No one else may be present in the room during this procedure and watches, bracelets and other reflective jewellery should be removed.
- Under no circumstances must direct viewing of the laser beam be attempted even if the beam has been attenuated.
- All optics should be checked for damage, and the stability of optics mounts verified prior to operation of laser.
- This next stage in alignment should be carried out using the lowest possible laser energy (e.g. operating a Nd:YAG laser on fixed-Q) at which it is possible to visualise the laser beam in an appropriate fashion. The method of visualisation is dependent on the wavelength: for UV or visible light, the beam can be viewed on a fluorescent card. An invisible infrared beam may be visualised using LCD heat sensitive paper or possibly using burn paper or a laser power meter.
- In the case of UV or IR beams, appropriate laser safety eyewear should be worn during the alignment procedure at all times when the laser pulse energy exceeds the ELV: note that it should not block the wavelength-shifted visible fluorescence (UV) or the heat effect on LCD paper or burn paper (IR), which can then be used to visualise the beam.
- Visible or multi-wavelength alignment may have to be carried out without laser safety eyewear, as it would otherwise be impossible to visualise the laser beam on a card. The option of using eyewear for visible alignment work (i.e., conforming to BS EN 208) should be considered if the beam power/energy cannot be reduced below the ELV. In this case extra caution must be exercised by the operator(s) after appropriate consideration of alternatives and assessment of risks. The laser(s) should be operated below the ELV if possible and in any case at the lowest practicable pulse energy. Blocking of possible stray reflections must be double-checked prior to carrying out this stage.
- Alignment of each laser beam to variable diameter apertures (iris diaphragms) should be employed where possible to minimise the necessity for multi-wavelength alignment.
- Further alignment at full power may be carried out in accordance with the protocol outlined under ‘day-to-day operation’.

Laser safety protocol: Adding new elements

Definition

Adding new elements applies to the introduction of any new optic into the beam path of a Class 4 laser such as a lens or filter.

Protocol/Scheme of work

Planning:

- The placement of additional optics should be planned to minimise the possibility of stray reflections.
- Beam blocks should be devised to terminate any unavoidable stray reflections.

Initial safety checks:

- Before starting the Class 3B/4 lasers, beam paths should be inspected for any objects that should not be there and beam pipes should be replaced if necessary.
- Laser warning signs should be activated, unauthorised persons excluded and laboratory doors closed.
- Alignment may be carried out by one or at most two authorised laser operators. No one else may be present in the room during this procedure and watches, bracelets and other reflective jewellery should be removed.
- Appropriate laser safety eyewear should be worn if practicable. Visible or multi-wavelength alignment may have to be carried out without laser safety eyewear, as it may otherwise be impossible to visualise the laser beam on a card. The option of using eyewear for visible alignment work (i.e., conforming to BS EN 208) should be considered if the beam power/energy cannot be reduced below the ELV.
- In this case extra caution must be exercised by the operator(s).
- All optics should be checked for damage, and stability of optics mounts verified.

Initial alignment and suppression of stray reflections:

- Once a new optic is in place, initial alignment should be performed with a Class 1 or 2 alignment laser (e.g., He-Ne or small diode laser). For simple optics it may be judged sufficient to proceed to the next step without using a Class 1/2 alignment laser.
- The new optic element in the beam path must be analysed for stray reflections. This can be done by predicting the likely path of specular (i.e., non-diffuse) reflections. The actual reflections of the Class 1/2 alignment laser may also be used to help identify stray reflections.
- Suitable beam blocks, opaque at the appropriate wavelengths, must then be installed to block all these stray reflections.
- Any effect ‘downstream’ of the new optic should be checked. ‘Beam pipes’ should be re-installed at this stage.

Alignment using Class 3B/4 lasers at low power:

- This may now be carried out in accordance with the procedure outlined under ‘setting up’ with the exception that explicit permission of a supervisor is not deemed necessary for addition of a simple optical element. (Anything more complex should be taken as ‘setting up’ and the protocol followed accordingly.)

Laser safety protocol: Day-to-day running

Definition

Day-to-day running applies to the operation of Class 3B/4 lasers under all circumstances except setting up or addition of a new optic element. It includes initial, minor realignment of laser beams at the beginning of an experimental run and 'tweaking' of alignments during an actual experiment.

Protocol/Scheme of work

Initial safety checks:

- Before starting the Class 3B/4 lasers, beam paths should be inspected for any objects that should not be there, and beam pipes should be replaced if necessary.
- Laser warning signs should be activated, unauthorised persons excluded, and laboratory doors closed.
- Alignment may be carried out by one or at the most two authorised laser operators. No one else may be present in the room during this procedure and watches, bracelets and other reflective jewellery should be removed.
- Appropriate laser safety eyewear should be worn if practicable. Visible or multi-wavelength alignment may have to be carried out without laser safety eyewear, as it would otherwise be impossible to visualise the laser beam on a card. The option of using eyewear for visible alignment work (i.e., conforming to BS EN 208) should be considered if the beam power/energy cannot be reduced below the ELV.
- In this case extra caution must be exercised by the operator(s).
- All optics should be checked for damage, and stability of optics mounts verified.

Check using Class 3B/4 lasers at low power:

- Before turning on full power, the beam path of each laser should be verified in turn, using the lowest possible pulse energy and visualising the beam in an appropriate fashion (e.g., on fluorescent card).
- Under no circumstances must direct viewing of the laser beam be attempted even if the beam has been attenuated. There must be no exceptions to this rule.

Minor realignment ('tweaking') with lasers running at full power:

- During an experimental run, it will sometimes be necessary to re-optimise the alignment to recover lost signal. Of necessity, this can only be carried out at full power, with all lasers on. Extra caution should therefore be exercised.
- All beam guards/pipes and blocks for stray reflections should remain in place during this procedure. Beam pipes should be designed to allow limited access to the beam for alignment checking without removal.
- It is especially important to wear appropriate laser safety eyewear when visualising laser beams at full power. As before, in a visible or multi-wavelength experiment this may not be practicable, and extra caution should therefore be exercised. The option of using eyewear for visible alignment work (i.e., conforming to BS EN 208) should be considered if the beam power/energy cannot be reduced below the ELV.

- It may be possible (and indeed, preferable) to apply minor 'tweaks' to the alignment using the experimental signal as a guide. In this case it is not necessary to visualise the laser beams.
- Cameras for remote viewing and the incorporation of remote adjustment aids should be promoted and used where reasonably practicable.

Laser safety protocol: Servicing

Definition

Servicing is the performance of those procedures or adjustments described in the manufacturer's service instructions which may affect any aspect of the product's performance. It can include activities such as the removal and reinstallation of optics for cleaning, the changing of laser dyes, the changing of flash lamps, and the installation of new optics inside the laser cavity. Entry into the laser enclosure potentially exposes the laser worker to additional non-optical hazards, for instance those associated with high voltages, and toxic chemicals, in addition to accessing high energy laser beams which are normally enclosed. The activities are very diverse, and specific protocols will need to be prepared for each laser, this document provides some general guidelines on the planning of *Maintenance*.

Protocol/Scheme of work

Where servicing is under a maintenance contract or service agreement, then access arrangements for service engineers (contractors) are required.

These will include how they should be managed together with any handover arrangements or restrictions that may apply. Copies of risk assessments and method statements should be requested in advance of the engineer attending site and work should not progress unless these have been provided. Where the engineer intends to carry out work with open beams of Class 3B or 4, they should also be asked to provide copies of their local rules and again work should not proceed without these.

Planning:

- Before commencing the work, the manual for the laser system should be consulted, to identify the recommended procedure.
- In the case of anything other than routine maintenance, and/or when the laser manual does not give a procedure, the advice of a laser technician should be sought. Some procedures should only be conducted by an experienced laser technician.
- The hazards associated with the procedure should be assessed, the control measures reviewed, and the conclusions recorded. In the case of some regular maintenance procedures (such as changing the dye solution in a dye laser), reference to an existing protocol may well suffice.
- Work involving the alignment of a laser beam inside a laser enclosure, for instance introducing the pump laser into a dye laser, can lead to an increased laser radiation exposure risk, since part of the beam path of a normally enclosed, and potentially very high power beam is likely to be open. The protocol for Setting Up should be consulted.

A SIGNATURE SHEET WILL ACT AS A LIST OF AUTHORISED USERS AND A RECORD THAT PERSONS HAVE BEEN GIVEN INFORMATION AND AGREE TO FOLLOW THE PROCEDURES LAID OUT.

Signature Sheet

This sheet must be signed by all workers before commencing work with Class 3B/4 lasers. By signing below, you confirm that you have read this document, you understand the requirements and that you agree to abide by the protocols and guidelines contained herein.

Name (in block letters)	Signature	Date

Appendix 5 – Example Scheme of Work for simple set-up

Laser Scheme of Work	**Class 4, 3 W, 635 nm Diode Laser (CW)** **in** *Location, Department, Premises*
Experiments:	Photodynamic therapy in vitro and vivo.
Person responsible:	Prof A N Other
Authorised operatives:	Prof A N Other, Dr L Aser

General Precautions

1. Only the above named personnel are permitted to use this laser. They must be familiar with the manufacturer's and the Institution's safety information (*including this Scheme of Work).*
2. When not in use the key to the laser (or other means of controlling access) should be kept separately from the laser, to prevent unauthorised use.
3. All beam paths shall be kept as short as possible and enclosed whenever reasonably practicable.
4. The area in which this laser is used should be a designated laser area, and have the appropriate warning notice on the door.

Specific considerations relating to this experiment

The laser should be sited at least 1.1 m away from the window, (NOHD is 1.09 m) and the blinds should be closed (Note: the blinds being closed will also reduce the risk of dazzle outside the room, which is a matter that needs to be considered in an AOR risk assessment).

The laser must be aligned using the lowest practicable power setting; if the lowest possible setting is below the ELV there will be no need for eyewear.

Before switching the laser on:

1) The fibre optic head must be securely mounted and pointing vertically down on to a non-reflective surface.
2) The appropriate safety eyewear should be worn, if the lowest power setting is above the ELV (assuming a 1 mm beam diameter, the requirement is D LB6 at 635 nm; the scale number may well be higher for larger beam diameters). Only those wearing safety eyewear are permitted in the operating area.
3) The 'Laser in Use - Do Not Enter' sign should be posted on the entrance door.

The laser should not be left unattended unless a remote interlock connector linked to the door prevents unauthorised access.

Because of the diverging nature of the beam the eye and skin hazard from these laser experiments is low. The only other hazard identified with this work is from the cabling. All cabling should be tied/taped back away from the operating area to prevent any tripping hazard and damage to the alignment of the fibre optic.

Copies of this Scheme of Work should be issued to all personnel using the laser, and should also be posted in the laboratory.

Departmental Laser Safety Officer ……………………………… Date ....

Appendix 6 – Summary of Warnings & Protective Control 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 will be necessary 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 that could be struck by an errant beam, 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 -1 and PD IEC/TR 60825-14 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 7 - Guidance on Manufacturer's and User Requirements

1	Remote interlock	Class 3R, 3B and 4 laser products – permits easy addition of external interlock in laser installation. Not required for some products in Class 3B
2	Safety interlocks in protective housing	Designed to prevent removal of the panel until accessible emission values are below that for Class 3R. For Class 3R, 3B and 4 laser products, designed to prevent removal of the panel until accessible limits are below that for Class 3B or £R for some products
3	Key control	A key or similar device is required to control unauthorised operation of Class 3B and Class 4 lasers. Laser inoperative when key is removed
4	Emission warning device	An audible or visible warning when laser is switched on or if capacitor bank of pulsed laser is being charged. For each Class 3R laser, only applies if invisible radiation is emitted and each Class 3B and Class 4 laser system product
5	Beam stop or attenuator/shutter	Should be provided by the manufacturer for each Class 3B or Class 4 laser system
6	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)
7	Beam level	Avoid eye level
8	Beam enclosure	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.
9	Eye protection	Required for open beam work with invisible beam Class 3R and all Class 3B and Class 4 devices.
10	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
11	Eye examinations	Only required after an accident but may be important to people with poor eyesight working with Class 3B or Class 4 lasers
12	Training	Required for people working with any Class 3R, Class 3B or Class 4 laser and any modified Class 1M or Class 2M devices.
13	Laser labels	Required for all lasers except low power Class 1 (though need not be directly affixed if the size of the laser product does not permit this)
14	Door/Area signs	Required for Class 3B and Class 4 lasers indoors and also for Class 1M, 2M and 3R if used outdoors

Appendix 8 – The Safe Use of Laser Pointers

Small lasers are commonly available and some are used for presentation purposes as pointers. In the past laser pointers were only available in red wavelengths and had output powers up to and sometimes over 5 mW. Nowadays devices are available emitting green wavelengths, where the eye is more sensitive and lower powers are all that is needed, so that laser pointers now only need to be Class 2 devices (output < 1 mW).

NB Class 1 laser products are normally safe.

Class 2 and Class 3R products are not hazardous under certain conditions, however they can cause harm to the eyes particularly if the beam is stared into.

Class 3B or Class 4 laser pointers must not be used.

Normally the eye's natural aversion response affords protection to short duration accidental exposure to Class 2. Class 1 or Class 2 laser pointers are the recommended choice where a laser pointer is necessary and are the only type that should now be purchased. Be cautious of purchasing online or being given gift laser pointers at conferences/exhibition.

Laser pointers should only be used as a pointing device and securely stored when not in use. Persons who use laser pointers should ensure that they are aware of potential hazards and they should comply with the basic instructions below.

Instructions for use
When operating laser pointers, users must ensure that they use them in a safe manner and do not expose themselves or others to the beam. Laser pointers are not to be modified in any way.

✓	• **Follow the manufacturer's safety instructions.** • **Take care when operating the laser pointer.** • **Keep the 'on' button depressed only when necessary.**
🚫	• **Do not keep the 'on' button depressed when not pointing at the screen.** • **Do not point at or towards the audience.** • **Do not point at mirrored surfaces.** • **Never look into the laser aperture.** • **Never look directly or stare into the beam/beam aperture when on.** • **Never allow unauthorised use, especially by children.**

Further guidance on laser radiation: safety advice including laser pointers published by PHE (published 15th August 2017) can be found at:- https://www.gov.uk/government/publications/laser-radiation-safety-advice/laser-radiation-safety-advice

Appendix 9 – Example Emergency Procedure – Eye Exposure

EXAMPLE OF EMERGENCY PROCEDURE
FOR EXPOSURE TO RADIATION FROM A CLASS 3B OR 4 LASER

Report to *NAME and ADDRESS of agreed A&E Centre (Eye Injuries)* **as soon as possible and within 24 hours of the incident.**

Do not drive yourself; get a friend or colleague to take you.

Out of hours: **Contact local Security or Emergency Services**

i. State Building and Department
ii. Location and nature of incident/accident
iii. Request assistance to take the casualty to the **** (as above)
iv. Take the card below to the Hospital

EMERGENCY OPHTHALMIC EXAMINATION - LASER beam Exposure	
Report to: **Accident and Emergency Department, ****** **Address** **Tel: ****************	
LASER DETAILS:	
i. Type:	**Continuous Wave / Pulsed***
ii. Wavelength:	**………………………………nm**
ii. Power Output (CW):	**…………………………….…**
or Pulse Energy, Duration, and Rate (pulsed):	**…………………………….…**
iv. Laser Classification:	**…………………………….…**
INSTITUTION NAME:	**School/Department** **…………………………….…**
EXPOSURE DETAILS:	
i. Circumstances of accident/injury:	**………………………………….**
ii. Time/Date of Injury	**………………………………….**
iii. Eye affected:	**Left/Right/Both***
iv. Were protective goggles being worn?	**Yes/No***
	* delete as appropriate
REPORT ACCIDENT/INCIDENT to local HEALTH and SAFETY Office **Ext ******* during normal hours**	

All accidents and incidents, whether involving an emergency examination or not, must be reported promptly to the Health and Safety Office using the current Institution Accident/Incident Report Form.

The Laser Safety Adviser and School/Departmental Laser Supervisor/Officer must also carry out a detailed investigation of the accident/incident.

The Reporting of Injuries, Diseases and Dangerous Occurrences (Amendment) Regulations 2013 requires any blinding and injuries causing reduction in sight to be reportable when a doctor diagnoses that the effects are likely to be permanent. Further guidance on RIDDOR available on HSE website, http://www.hse.gov.uk/riddor/.

Appendix 10 – 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 the Health & Safety (Safety Signs and Signals) Regulations 1996. BS ISO 3864-1:2011, *Graphical symbols. Safety colours and safety signs. Design principles for safety signs and safety markings* published September 2011 has replaced BS 5499-1:2002.

The signs shall incorporate the following information:

1) hazard warning symbol

For the area signs the specifications are quite simple - 50% of the area should be yellow and the width of the black border is 0.06 x the length of the side.
A more detailed specification is given for the symbol used in labels, see spec on in BS EN 60825-1

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 BS EN 60825-1.

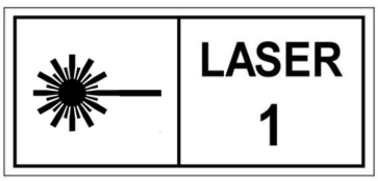
Where the size of the laser product does not permit the affixing of a reasonably sized label, a sign should be displayed in close proximity to the laser with all appropriate information on. Information over and above that specified by BS EN 60825-1 is required for Class 1 products that are Class 1 by engineering design. For these types of laser product we specify that they are totally enclosed systems and give details of the laser enclosed. The BS requirement is just to describe them on the outside as a Class 1 laser product.

Access panels need to be labelled with the accessible laser information

Details of wording required on explanatory labels are given below.

Class 1 (by engineering design)

No hazard warning label (informative label).



Explanatory label bearing the words: **CLASS 1 LASER PRODUCT**
A TOTALLY ENCLOSED LASER SYSTEM
CONTAINING A CLASS ..... LASER

In addition, each access panel or protective housing shall bear the words:-

CAUTION - CLASS .... LASER RADIATION WHEN OPEN

with the appropriate class inserted and then followed by the hazard warning associated with that class of laser (see warning statements in following labels).

Class 1M

No hazard warning label.

Explanatory label bearing the words:

LASER RADIATION
DO NOT EXPOSE USERS OF
TELESCOPIC OPTICS

or as an alternative:

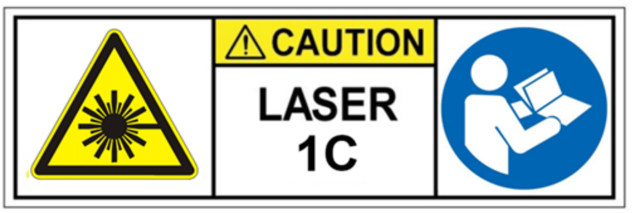
Class 1C

Label with hazard warning symbol.

Explanatory label bearing the words:-

LASER RADIATION
FOLLOW INSTRUCTIONS
CLASS 1C LASER PRODUCT

or as an alternative:



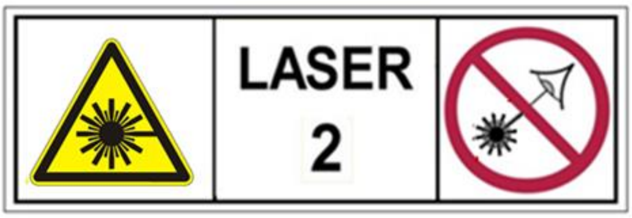
Class 2

Label with hazard warning symbol.

Explanatory label bearing the words:-

LASER RADIATION
DO NOT STARE INTO BEAM
CLASS 2 LASER PRODUCT

or as an alternative:



Class 2M

Label with hazard warning symbol.
Explanatory label bearing the words:-

LASER RADIATION
DO NOT STARE INTO BEAM OR EXPOSE
USERS OF TELESCOPIC OPTICS
CLASS 2M LASER PRODUCT

or as an alternative:

Class 3R

Label with hazard warning symbol.
Explanatory label bearing the words:-
For λ 400 nm – 1400 nm ONLY.

LASER RADIATION
AVOID DIRECT EYE EXPOSURE
CLASS 3R LASER PRODUCT

NB - For other λ replace 'AVOID DIRECT EYE EXPOSURE' with 'AVOID EXPOSURE TO BEAM'

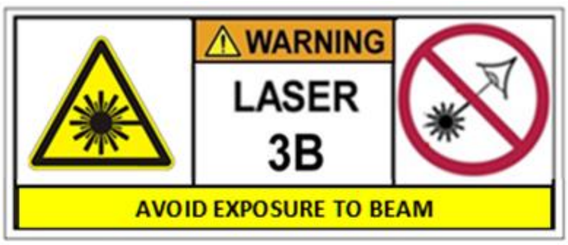
or as an alternative:

Class 3B

Label with hazard warning symbol.
Explanatory label bearing the words:-

WARNING - LASER RADIATION
AVOID EXPOSURE TO BEAM
CLASS 3B LASER PRODUCT

or as an alternative:



Class 4

Label with hazard warning symbol.
Explanatory label bearing the words:-

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

or as an alternative:

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

Each Class 3R, Class 3B and Class 4 laser product shall display a label close to where the beam is emitted bearing the words 'LASER APERTURE' or 'AVOID EXPOSURE – LASER RADIATION IS EMITTED FROM THIS APERTURE'.

LASER APERTURE

or

AVOID EXPOSURE – LASER RADIATION IS EMITTED FROM THIS APERTURE

This label can take the form of an arrow if this displays more meaning:-

Radiation Output and Standards Information

All laser products, except for low power Class 1 devices, shall be described on an explanatory label with details of:-

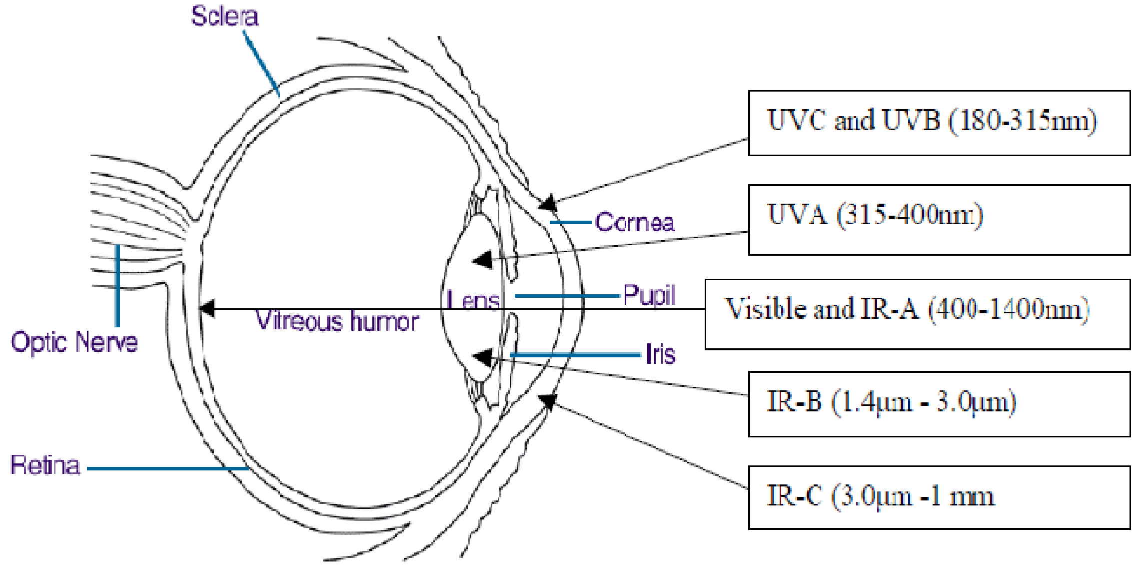
- maximum output
- emitted wavelength
- whether laser beam is visible, invisible or both
- pulse duration (if appropriate)
- name and publication date of classification standard

It may be found useful to also put on the labels details of the type of laser and the lasing medium, although this is not a BS requirement.

Information put on explanatory labels may be combined.

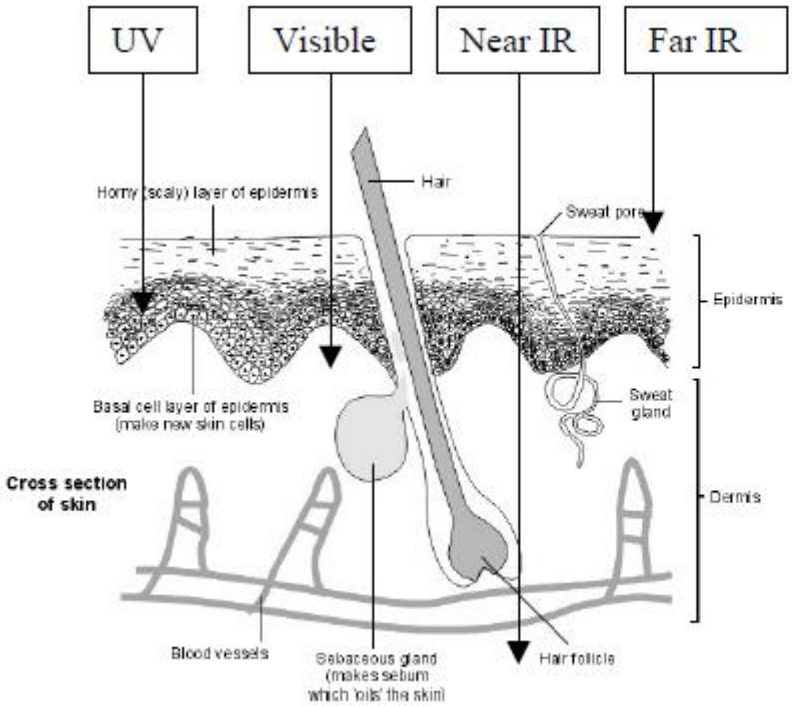
Appendix 11 – Optical Hazards and Biological Effects of Laser Radiation

Penetration of laser radiation into the eye



NB Short pulsed high peak-power laser beams are particularly hazardous to the eye, especially 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



In general, the skin can tolerate a great deal more exposure than the eye and less research has been done on damage mechanisms. All wavelengths of laser output with sufficient power density can cause surface burns of the skin and with high-powered Class 4 lasers there could 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 and UV lasers are also of concern because of the long-term risk of developing skin cancer.

Summary of biological effects associated with excessive exposure to optical radiation
CIE Spectral Region + Eye Skin

CIE Spectral region+	Eye	Skin	
Ultra-violet C (180 nm to 280 nm)	Photokeratitis	Erythema (sunburn) Increased risk of skin cancer Accelerated skin ageing process Increased pigmentation	
Ultra-violet B (280 nm to 315 nm)			
Ultra-violet A (315 nm to 400 nm)	Photochemical cataract	Pigment darkening Photosensitive reactions	Skin burn
Visible (400 nm to 780 nm)	Photochemical and thermal retinal		
Infra-red A (780 nm to 1400 nm)	Cataract, retinal burn		
Infra-red B (1.4 m to 3.0μm)	Aqueous flare, cataract corneal burn		
Infra-red C (3.0 m to 1 mm)	Corneal burn only		

+ The spectral regions defined by the CIE are shorthand notations useful in describing biological effects and may not agree perfectly with spectral breakpoints in the ELV tables.

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

Appendix 12 – Resources and Links

RESOURCES & LINKS

Information sources

Public Health England. Safety advice including laser pointers (published 15th August 2017).
https://www.gov.uk/government/publications/laser-radiation-safety-advice/laser-radiation-safety-advice
This describes the properties of laser radiation and provides safety advice on devices such as laser pointers and laser pens.

Public Health England. Ubiquitous Lasers.
PHE publications gateway number: 2014792, February 2016.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/496266/Ubiquitous_Lasers_StdQ.pdf

This is an illustrated booklet giving an introduction to lasers and laser safety. It includes information on laser beam interactions with the eye and skin, legislation governing laser use, laser classification, and practical laser safety.

Laser Safety Forum, run by Public Health England and Loughborough University. Annual meeting and periodic newsletter/update emails. Details of the next meeting are available at :-
https://www.phe-protectionservices.org.uk/nir/courses/

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

Medicines & Healthcare products Regulatory Agency. Lasers, intense light source systems and LEDs – guidance for safe use in medical, surgical, dental and aesthetic practices. September 2015.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/474136/Laser_guidance_Oct_2015.pdf

The MRHA guidance document covers medical lasers, light emitting diodes (LEDs), intense light/heat sources, referred to as intense pulsed light (IPL) (sources) and equipment used in conjunction with the optical radiation equipment, such as optical fibres.

Civil Aviation Authority. If it is intended to use lasers outdoors one must consult the Civil Aviation Authority (CAA) guidelines:-
CAP 736: Operation of Directed Light, Fireworks, Toy Balloons and Sky Lanterns within UK Airspace. http://publicapps.caa.co.uk/docs/33/CAP736.PDF

Health & Safety Executive (HSE) information and guidance on optical radiation:- http://www.hse.gov.uk/radiation/nonionising/optical.htm

Health & Safety Executive (HSE) has produced guidance to help duty holders decide whether they are already protecting their workers or whether they need to do more under the new regulations.

Guidance for Employers on the Control of Artificial Optical Radiation at Work Regulations (AOR) 2010

In addition, the European Commission non-binding guide to good practice for implementing Directive 2006/25/EC covers applications posing minimal risk and provides guidance on others. An assessment methodology is set out and outlines measures to reduce hazards and check for adverse health effects. This publication is available in electronic format in all EU official languages.

A non-binding guide to the Artificial Optical Radiation Directive 2006/25/EC

Personal protective equipment at work (Second edition)

Personal Protective Equipment at Work Regulations 1992 (as amended). Guidance on Regulations. L25. Publisher: HSE Books, 3rd Edition 2015.

RIDDOR Guidance….HSE website http://www.hse.gov.uk/riddor/

NPL/AWE Laser Safety Videos

Funded by AWE (the Atomic Weapons Establishment) and the MOD (Ministry of Defence), NPL has created four Laser Safety Videos. These videos are freely available to hospitals and academic establishments. The four videos (MP4 format) cover Laser Controlled Areas; Laser Alignment; Laser Eyewear and Filters and Laser Classification.

To download the videos, please complete the following form on the website at:

http://www.npl.co.uk/optical-radiation-photonics/laser-safety-videos

Appendix 13 – Example Training Record

TRAINING RECORD FORM - AUTHORISED LASER USER

Researcher ………………………………………………

Room number ………………………………………………

Lasers used ………………………………………………

………………………………………………

………………………………………………

………………………………………………

☐ Attended Institution training lecture

☐ Registered as Institution laser user

☐ Read Institution Policy/Guidance for laser safety

☐ Familiar with all hazards within the laboratory and the laboratory's risk assessment

☐ Trained in use of lasers named above

☐ Familiar with laser Schemes of Work

SIGNED

Researcher ……………………… Date ……………………

Supervisor ……………………… Date ……………………

RETURN THIS FORM TO YOUR DLSO