Code of Practice on the Use of High-Power Lasers

Policy

Introduction

LASER stands for Light Amplification by Stimulated Emission of Radiation. A laser when activated can produce a very intense, monochromatic and narrow beam of electromagnetic radiation which makes it more hazardous than other conventional light sources. A laser emits non-ionizing radiation in the ultraviolet, visible or infrared ranges. Depending on the type and wavelength of the laser used, the hazard is mainly on the eyes (lens, cornea, and retina) and the skin. Biological damage includes photochemical injuries, retinal injury, and thermal burns. Lasers that emit radiation outside the visible range are particularly hazardous.

Lasers are found in a number of applications in laboratories or workshops either as stand-alone lasers or as parts of equipment. There are two operation modes of laser: continuous wave (CW) and pulsed (P). Pulsed lasers are generally more hazardous than CW lasers.

Classification

It is the responsibility of the manufacturer or its agent to provide the correct classification and label of a laser. If a laser is modified, the person or organization performing such modification is responsible for reclassification and relabeling of the laser product.

Lasers are grouped mainly into 4 classes according to their potential hazards and the maximum accessible laser radiation during normal operation. The higher the power of a laser, the greater the hazard, and the higher the class it belongs to. All laser equipment in the University must be classified and labeled according to one of the following or other equivalent standards:

- IEC 60852-1
- ANSI Z136.1
- BS EN 60825
- AS 2211

Appendix 1 of this Code shows the characteristics of the different classes of lasers according to the classification of IEC 60852-1. Classification systems in other standards are either based on or similar to the IEC 60852-1. However, some lasers currently available on the market may be classified in a different way for various reasons. Please consult the Safety Office if there are any queries.

For the purpose of this Code, high-power lasers are those classified as Class 3B or 4. These lasers can cause serious injuries if not properly controlled.

In view of the special nature and operational requirements of medical or surgical lasers, the recommended control measures in this Code are not intended to apply to them.

Responsibilities

Department Head:

A department where high-power lasers are used should keep a detailed record of all such lasers. The record should contain at least the following information:

- Description of the laser (e.g. lasing medium, power, mode of operation – CW/P)
- Classification of the laser
- Location
- Person-in-charge of the laser

A Principal Investigator or Person-in-Charge of a High-Power Laser is:

- To ensure that the laser equipment is properly classified and labeled by the laser equipment manufacturer or according to international standards if modifications are made.
- To inform the Safety Office (SO) on any purchase of new high-power laser equipment in advance, and to register such laser with the SO. The relevant registration form in Appendix 2 should be filled in and returned to the SO.
- To ensure control measures are considered before the purchase of the equipment and to include the appropriate safety features in the planning of the laboratory. The requirements for a laboratory housing high-power lasers are given in Appendix 3. A laboratory or any other area housing a high-power laser is called a Laser Controlled Area.
- To establish and keep up-to-date a written standard operating procedures (SOP) for the use of each high-power laser, and to make the SOP readily accessible in a Laser Controlled Area.
- To notify the SO on any changes to the registered laser under his control.
- To train or to arrange training for all users of the registered laser on the health and safety of lasers and the safe operation of the specific equipment.
- To ensure that sufficient and appropriate protective equipment (e.g. eye protection) is provided and used where necessary.
- To regularly inspect the conditions of the registered laser and the Laser Controlled Area to ensure safety.

A User of High-Power Laser is:

- To attend training on the safe use of lasers when provided.
- To operate the laser equipment according to the SOP.
- To use PPE provided by the department where necessary.
- Not to permit the entry of unauthorized personnel into the Laser Controlled Area where a high-power laser is operating.
- To report any incident or accident to the Principal Investigator or Person-in-charge of the laser.

Guidance

Safety Requirements for Laser Controlled Area

A Class 3B or 4 laser can be converted to a lower class by totally enclosing the lasing beam with an appropriate enclosure. If any part of the beam is exposed, the high-power laser should be operated in a Laser Controlled Area, which could be a room dedicated for the purpose or part of a room physically separated from other areas in the room.

A Laser Controlled Area must have the following features:

- Warning light and signs at the entrance
- Access control to the area
- Appropriate eye protection for people inside the area
- Standard Operating Procedure

(Please refer to Appendix 3)

For a Laser Controlled Area with more than one laser, appropriate shielding or barrier for individual lasers are normally required.

General Safety Measures for Working with Lasers

The following are general safety measures that apply to work with high-power lasers in general. They should be practiced in addition to the specific Standard Operating Procedure.

- Do not work with or near a high-power laser unless trained and authorized to do so.
- Do not enter a Laser Controlled Area when the warning light is on and the laser is energized.
- Verify that all safety devices are in place before energizing a laser.
- Use a warning light or sound to indicate laser operation or ready to fire, especially for invisible beam such as from infrared lasers.
- Keep the laser beam path as short as possible and enclose it as much as possible.
- Terminate the beam at the end of its useful path.
- Orient the beam so that it is not directed towards entry doors, occupied areas or traffic paths.
- Confine the beam within a well-defined area such as an optical table.
- Make use of beam attenuator or beam stop to temporarily terminate laser emission whenever emission is not required for short periods; turn off the laser if the emission is not required for longer periods.
- Contain the laser radiation with the use of screens, blinds, or curtains.
- Place the laser beam well below or above eye level of any sitting or standing observers.
- Mount the laser firmly to ensure that the beam travels only along its intended path.
- Do not stare directly into the laser beam. Use appropriate eye protective equipment where necessary.
- Do not use optical viewing aids (e.g. binoculars, microscopes) with the laser unless the increased hazard due to magnification has been reviewed. If such aids are required, use the original aids provided by the manufacturer of the laser equipment.
- Eliminate specularly reflective material from the beam area as far as practicable. Remove watches, rings, etc while working in the beam area.

- Ensure that scattered laser radiation is not escaping through the windows, doorways and open portals to the outside.
- Use a protective housing over the laser such that the laser beam emerges from the aperture only. Place shutters, polarizers and optical filters at the laser exit port to reduce the beam to the minimal useful level.
- Establish a safe method of beam alignment.
- Discharge capacitors and turn off power before leaving a pulsed laser unit unattended. Never leave the laser unattended when it is in operation.
- Work with sufficient levels of room illumination.
- Maintain an uncluttered environment and well-organised working layout.
- Allow only competent and well trained persons to carry out the service or alignment on the laser.
- If a serious skin or fire hazard exists, use a suitable shielding between the laser beam and any personnel or flammable surfaces.
- Provide appropriate fire fighting equipment in the vicinity of the laser equipment for the control of possible small fires.

Non-Beam Hazards of High-Power Lasers

Besides the hazards arising from the laser beam, there are also other associated non-beam hazards which include electric shock, noise, fire and air contaminants generated during laser work. More information on some common non-beam hazards is given in Appendix 4.

Appendix 1

Class	Characteristics	Remark
1	Low laser emission or access to high laser emission not possible as totally enclosed. Safe during normal operation under most circumstances including the use of optical instruments for intra-beam viewing	If consists of a higher class laser enclosed in an interlocked housing, the laser system reverts to the classification of the embedded laser once the housing is removed.
1M	Safe but may be hazardous if optics like binoculars, telescopes, magnifying lenses and microscopes are used in the beam	Eye injury may occur with optical viewing instruments
2	Emit low levels of visible radiation (400-700 nm) where eye protection is afforded by natural aversion response to bright light including where optical instruments used for intra-beam viewing Maximum output power of 1 mW.	Safe for usual exposure. Only hazardous if the viewer overcomes natural aversion response to bright light and viewed directly for extended period of time.
2M	As for class 2, except that viewing may be more hazardous if optics are used in the beam	Eye injury may occur with optical viewing instruments
3R	Most class 3R lasers emit between 1-5 mW of visible radiation. Potentially hazardous under some direct and specular (mirror-like) reflection viewing if the eye is appropriately focused and stable.	Eye injury for intentional intrabeam (direct) viewing
3B	Maximum output power of 500 mW. Hazardous under direct or specular reflection viewing. Viewing of diffuse (scatter) reflections is normally safe. No significant skin hazard except for higher powered 3B lasers operating at certain wavelength. Generally not a fire hazard.	Serious eye injury for intentional intrabeam exposure even for short time exposure; SOP, administrative control and training required, medical surveillance suggested.
4	High-powered lasers, output power greater than 500 mW. Potential acute hazard to the eye and skin for both direct beams, specular and diffuse reflections. Potential fire hazard and air contaminants may be generated from target or process materials.	Serious eye and skin injury for both intrabeam and diffuse reflection exposure, potential fire hazard; SOP, administrative control and training required, medical surveillance suggested.

Class 2, 3, or 4 laser equipment contained in a protective housing during operation may be put in a lower classification. For example, a class 4 laser total enclosed properly may be reclassified as class 1 or 2.

Appendix 2

University of Hong Kong
Safety office
Registration of High-power Laser (Class 3B or 4)

Please complete one form for each Class 3B or 4 laser and submit to the Safety Office.

Person responsible:

Name of principal Investigator: _____ Phone no.: _____

Department: _____ e-mail: _____

Name of Laboratory contact: _____

Phone no.: _____ e-mail: _____ Number of laser users: _____

Details of the laser equipment:

Location of laser: Building: _____ Room no.: _____

Description of equipment: _____

Manufacturer: _____ Supplier: _____

Model: _____ Serial number: _____

Date of manufacture/Purchase: _____

Laser classification marked on laser: Class 3B □, Class 4 □, none □

Type of Lasing medium: _____ Output power: _____

Beam diameter at aperture: _____ (mm) Beam Divergence: _____

	□ Continuous Wave	□ Pulsed		
Wavelength	Maximum Power/Energy	Pulse Duration	Pulse frequency	Energy per pulse

Usage of the laser (please briefly describe):

_____

_____

Will operation of this laser generate hazardous vapour/fumes: Yes □ / No □

Signature of person responsible: _____ Date: _____

Appendix 3

Building Requirements for a Laser Controlled Area

A Laser Controlled Area should have the following safety features:

Control access

1. A Laser Controlled Area, such as a room separate from other laboratory area should be dedicated for the sole use of the laser only. The activities within it should be restricted to those directly related to the laser work.
2. The room should have access control, and be made only accessible to those directly involved in the laser work.

Safe entrance

3. The entrance door to the laser room should be interlocked to ensure that the laser beam is shut down when the door is opened to prevent exposure of unprotected persons. This interlock should be designed to fail to a safe condition. Locking the door to a laser controlled area as a means of control should not be used as this may cause serious safety risks in case of emergency.
4. The interlock system should be designed so that once operated the system can only be reset after all safety measures are resumed. The reset button should not itself restart the laser but should enable the start command of the laser equipment.
5. A fail-safe electrically operated shutter or beam stop can be interlocked with the entrance door to terminate the laser emission if it is not desirable to connect the door interlock to the power supply of the laser in case a long warm-up period is required to achieve a stable laser operation.
6. If access to a Laser Controlled Area is permitted with the laser in operation or an interlock override is fitted, the room layout should ensure that there is no direct line of sight from the laser to any entry point. A laser barrier such as an internal partition, screen or laser-resistant curtain is required to prevent direct viewing of the beam upon accidental entry into the room when the beam is energized. An audible alarm should also be installed to give warning when the door is opened. A small lobby area between the entry point and this barrier is useful to allow persons to put on eye protection (if required) before moving into the hazard area.

7. If the Principal Investigator or the Person-in-charge of a high-power laser is able to carry out a detailed risk assessment of the laser operation, and demonstrate that the relevant Maximum Permissible Exposure (MPE) of the direct, reflected and diffuse laser radiation for the eye and the skin will not be exceeded in any of the accessible parts of the Laser Controlled Area, the requirements on door interlock in paragraphs 3-6 above can be waived. This decision not to have the remote interlock however has to be clearly documented by the Principal Investigator or the

Person-in-charge. The assessment should be carried out in accordance with a relevant international standard such as ANZI Z136.1.

Proper warning

8. An illuminated laser warning sign should be installed outside the entrance to the Laser Controlled Area to indicate the operation of the laser. The light should be appropriately connected and activated by the operation of the laser so that it indicates “laser on. Do not enter” or “Laser radiation. Do not enter when light is on” whenever the laser is in operation. It should not be manually operated.

9. A standard laser warning sign (such as the ones shown below) should be posted at each entrance and also on the inside of the laser room to indicate the potential hazard.

10. It is also advisable to put other suitable warning labels on the door of the room to indicate controlled access. Examples include “Keep out! Authorized persons only” or “Eye protection must be worn”.

Building work

11. Walls and ceilings or other surfaces should be made non-reflective. This can minimize reflected laser beam.

12. For class 4 lasers, fire-resistant surfaces should be used near the laser beam.

13. Windows that are transmissive at the laser wavelength have to be covered by absorbing materials capable of withstanding laser irradiation without risk of fire or other damage. This is to ensure that scattered laser beam will not escape to the outside or be viewed by a passer-by.

14. Sufficient high level of room illumination should be maintained for clear vision through protective eyewear. This can also restrict the diameter of the pupil to reduce the retinal exposure. Light-coloured but diffusely reflecting surfaces can be used to achieve this.

15. Work area should be designed with adequate freedom of movement.

Others

16. Local exhaust ventilation for removal of any hazardous vapours or fumes generated should be provided if appropriate.

17. A chemical fume hood or other local exhaust ventilation must be available if hazardous chemicals will be used. If a chemical fume hood is installed, its glass sash should be positioned so as to make accidental reflection of the laser beam impossible.

18. The installation of emergency-stop button to terminate the laser emission in the event of emergency should be considered.

Appendix 4

Other Associated Health Hazards Arising from Lasers

Electrical hazard

Electrical hazard may arise from high voltage used by the laser and significant amount of electric charge stored in the capacitors. Prevent electric shock by enclosing all electrical terminals under normal operation. Fully discharge storage capacitors prior to any work inside high power laser equipment. Adopt safe working practices during equipment servicing when working in close proximity to live electrical terminals.

Hazardous substances and fumes

Handle, store and dispose of hazardous substances properly. Use minimum quantities of solvents and chemicals in well-ventilated areas. Use fume cupboards or glove boxes where appropriate. Install suitable local exhaust ventilation to remove fumes or air contaminants generated during the operation of the laser.

Noise

Noise may be generated from the discharge of capacitor banks within the laser power supply, from pulsed lasers or from air-coolers. Wear ear protectors when the excessive noise cannot be eliminated.

Fire and explosion

The emission from class 4 lasers can ignite target materials, solvents, dust and inflammable gases. Emission from lower class lasers can also cause explosion in flammable gases or in high concentrations of airborne dust. The high-pressure discharge lamps used in optically-pumped lasers can explode. Good house keeping and regular removal of waste are important. Suitable fire-fighting equipment should be available.

Mechanical hazards

Moving bulky equipment or gas cylinders, manual handling of large work pieces or other heavy items can cause mechanical hazards. There are also tripping hazards from trailing cables, gas tubing or water hoses. Use appropriate enclosure or guard for moving parts to minimize risk of mechanical hazards. Use also warning signs to warn about parts that may move unexpectedly or to indicate the range of possible movement.

Other collateral radiation

Ionizing radiation (x-ray) may be generated from the use of high electrical voltages in excess of 15 kV. There is also radio-frequency emission from RF-exited lasers if not properly screened. Use appropriate screening and enclosure to control this radiation.