LASER SAFETY

PAK IP

CIH, CLSO, RRPT, RSO

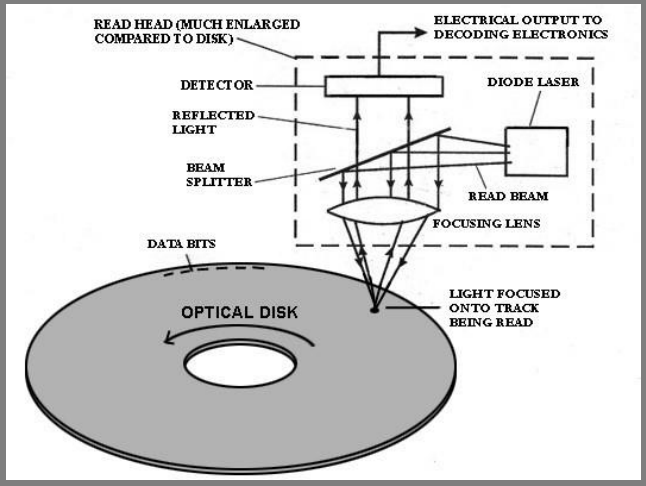
HEALTH SAFETY & ENVIRONMENT OFFICE

HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

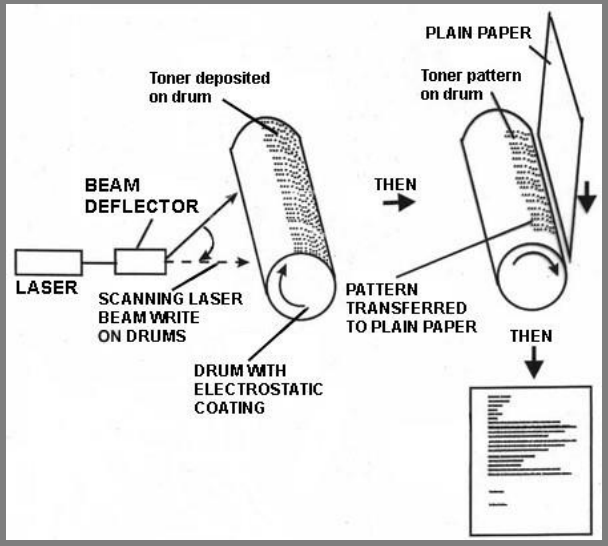
OBJECTIVE

- Descriptions of the various laser classifications
- Descriptions of the hazards associated with lasers
- Basic information you need to operate lasers safely and in conformance with HKUST(GZ) requirements

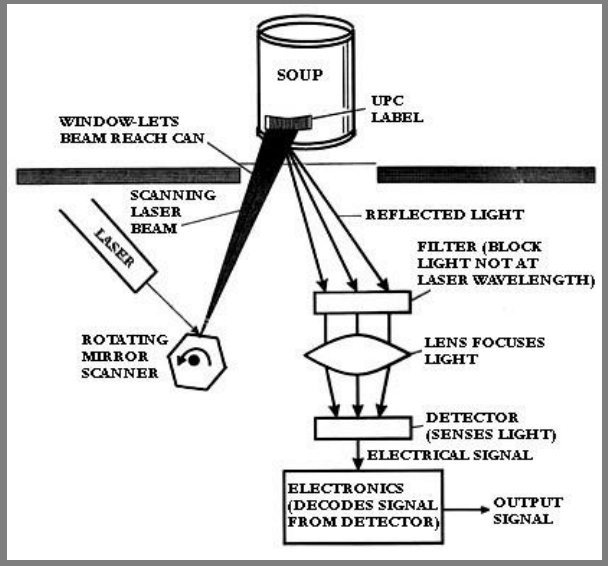
OPTICAL DISC SYSTEM



LASER PRINTER



LASER BAR-CODE READER



TERMINOLOGY

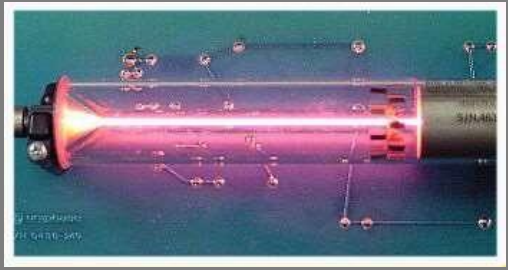
- Laser
  - acronym: Light Amplification by Stimulated Emission of Radiation
- Laser - a safety definition:
  - A highly collimated source of extremely intense monochromatic electromagnetic radiation

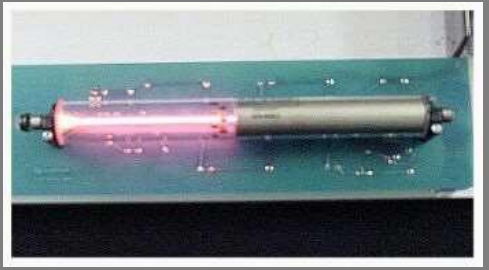
GOAL

- Avoid Exposures
- Reduce exposures to below Maximum Permissible Exposure (MPE):

  The maximum level of radiation to which human tissue may be exposed without harmful effect. MPE values are found in the ANSI Standard Z136.1 2014
- Achieved through basic safety controls

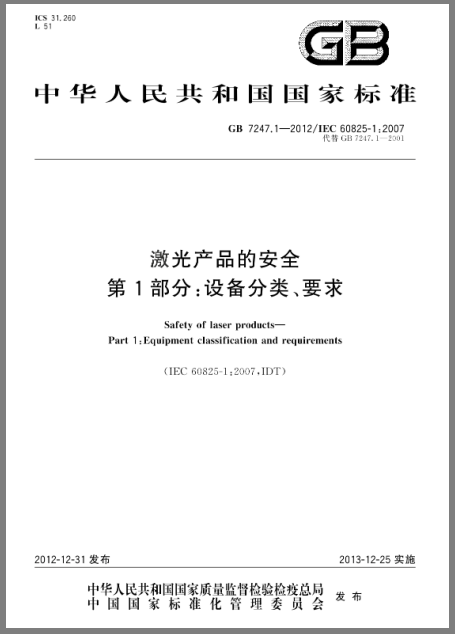
HELIUM NEON LASER





LASER POINTER

LASER STANDARD



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中华人民共和国国家标准

GB 7247.1—2012/IEC 60825-1:2007
代替 GB 7247.1—2001

激光产品的安全
第 1 部分:设备分类、要求

Safety of laser products—
Part 1:Equipment classification and requirements

(IEC 60825-1:2007,IDT)

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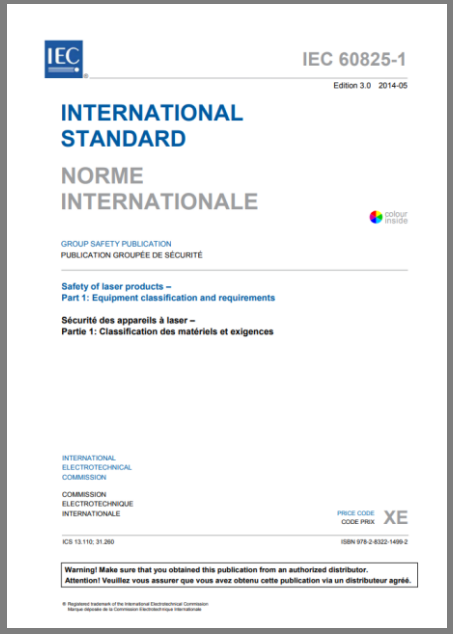

IEC

IEC 60825-1

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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PUBLICATION GROUPÉE DE SÉCURITÉ

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Part 1: Equipment classification and requirements

Sécurité des appareils à laser –
Partie 1: Classification des matériels et exigences

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LASER CLASSIFICATION

- Class 1: It is safe to be exposed to laser light during use, including long periods of direct beam invision, even when using optical viewing instruments (small eye magnifiers or binoculars).

- Class 1M: Direct beam invision is safe even with naked eye for a long time.

- Class 2: Laser products emit visible radiation in the wavelength range of 400 ~700 nm, which is safe for instantaneous irradiation, but intentional gaze of the laser beam may be harmful.

- Class 2M: Laser products emit visible laser beams, which are safe for naked eye exposure only for short periods.

LASER CLASSIFICATION

- Class 3R：The emission radiation of laser products may exceed that of MPE in direct beam vision, but the risk of damage is relatively low in most cases.

- Class 3B：Intrabeam ocular irradiation of laser products (i.e. within NOHD), including accidental short exposures, is generally harmful. It is generally safe to observe diffuse reflections.

- Class 4: Both beam invision and skin irradiation are dangerous, and viewing diffuse reflections can be dangerous. Such lasers also often cause fires.

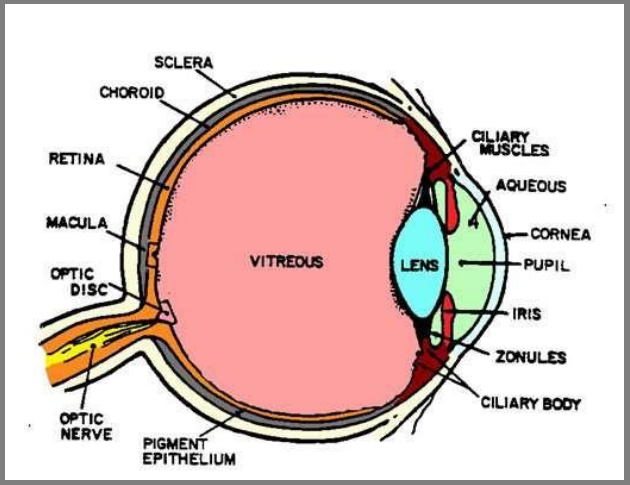
NATIONAL IGNITION FACILITY

GREEN LASER POINTER

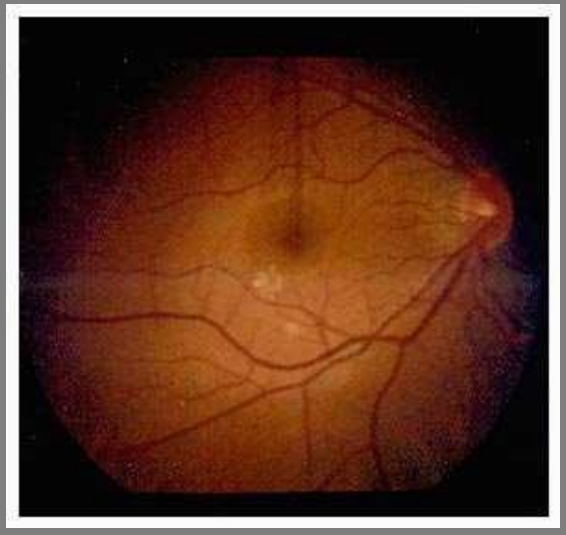
Output at 532 nm

Output at 1064 nm

LASER BEAM HAZARD: THE HUMAN EYE

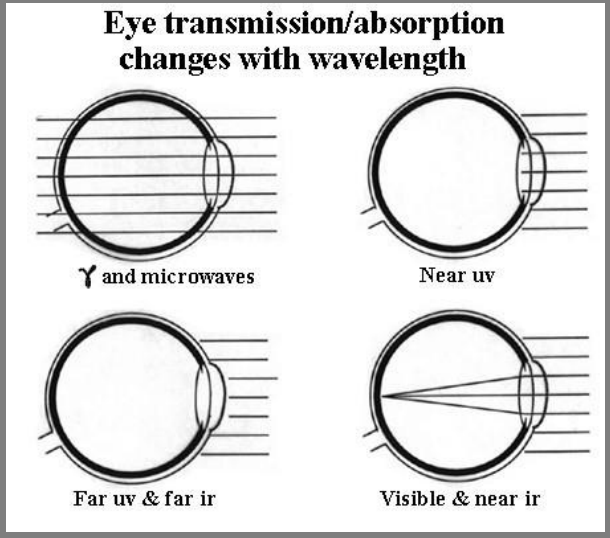


RETINA



BEAM HAZARD: EYES

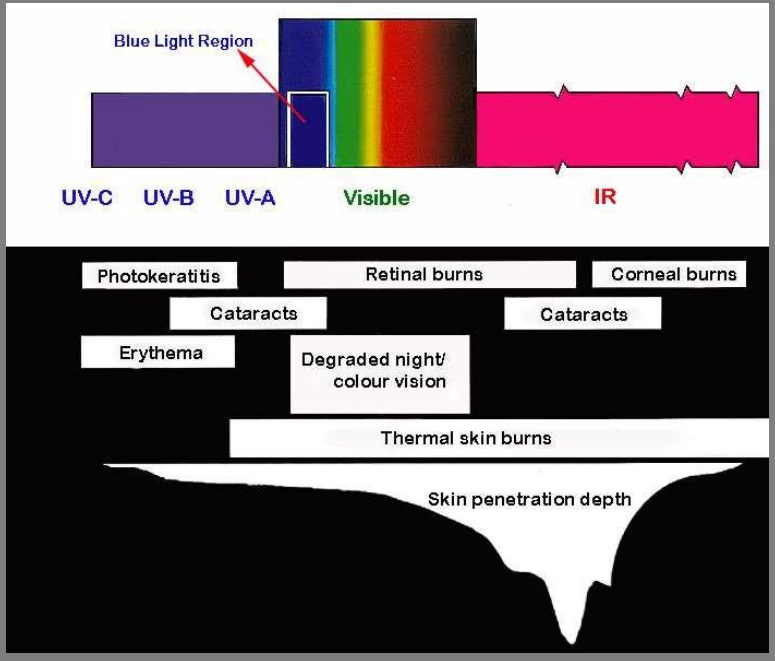
- The eyes are the most vulnerable organ, and the injury is frequency dependent
  - UV-B, UV-C and far-IR radiation are absorbed at the cornea
  - UV-A radiation is primarily absorbed in the lens
  - Visible and near-IR radiation are refracted at the cornea and lens, and absorbed at the retina
- The cornea and lens of the eye can be damaged by some laser frequencies
- The lens can focus light by 100,000 times to a 20 mm size point on the retina



BEAM HAZARD: SKIN

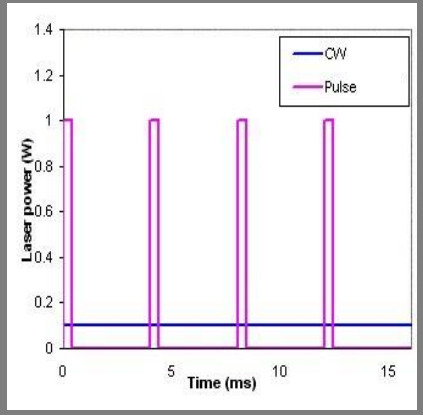
- 315 nm - 1 mm wavelength beams absorbed by the skin
- Thermal effects range from mild reddening (erythema) to blistering and charring
- Primarily minor burns
- Usually only with high-power lasers

BEAM HAZARD SUMMARY



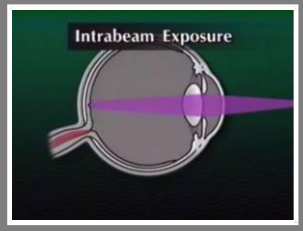
BEAM HAZARD FACTORS

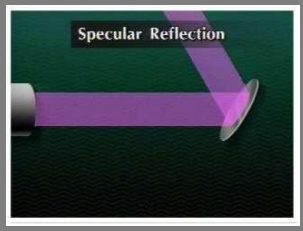
- Wavelength
- Intensity of radiant exposure
- Angle of beam incidence
- Exposure duration
- Pulsed versus continuous wave (CW)
  - More damaging, including retinal hemorrhaging

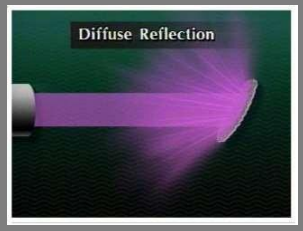


BEAM HAZARD FACTORS

- Direct beam/specular reflection/diffuse reflection
  - Direct viewing of a beam
  - Specular reflection - When an incident beam is reflected in primarily one direction, preserving its intensity (e.g. reflection from a mirror)
  - Diffuse reflection - When an incident beam is scattered in many directions, reducing its intensity (e.g. visible light reflection from a rough surface)







ELECTRICAL HAZARDS

- High-voltage current
- Victim provides a path to ground
- Fatal cases reported in US
- Assure adequate grounding and interlocks

DYE HAZARDS

- Dyes are frequently mutagenic (may be carcinogens)
- Little information on dye toxicity
- Solvents can carry dye through the skin
- Laser dye solvents can be volatile and/or toxic

GAS HAZARDS

- Excimer lasers can use fluorine or chlorine gas as lasing medium- extremely dangerous
- Carbon dioxide and liquid nitrogen (expands 700x)
  - - displace oxygen -
- Pressure safety issues

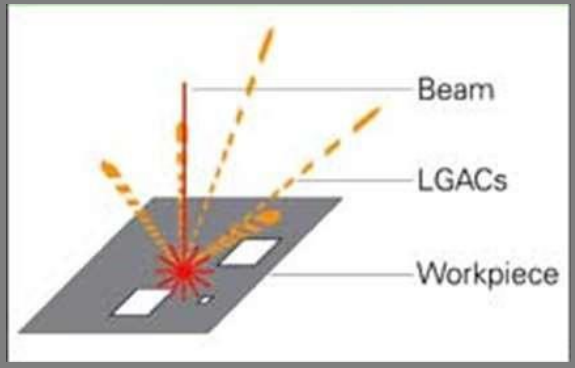
LASER GENERATED AIR CONTAMINANTS (LGAC)

- Aerosols and gases generated from interaction of high power laser beam with biological tissues or other materials
- Include various toxic or mutagenic chemicals
- Could carry infectious agents
- Usually odorous

CO_2 LASER CUTTING OF POLYVINYL CHLORIDE

Gaseous by-products

- Benzene
- Toluene
- Styrene
- Benzoaldehyde
- Ethyl benzene
- Hydrogen chloride



RADIATION HAZARDS

- Covered by HSE Radiation Safety Section
- X ray
- Non-ionizing Radiation
- Electric and magnetic fields

OTHER HAZARDS

- Noise (very high-power pulsed lasers)
- Explosions (faulty optical pumps and lamps)
- Cryogenic coolant hazards

SPECIFIC LASER OPERATION

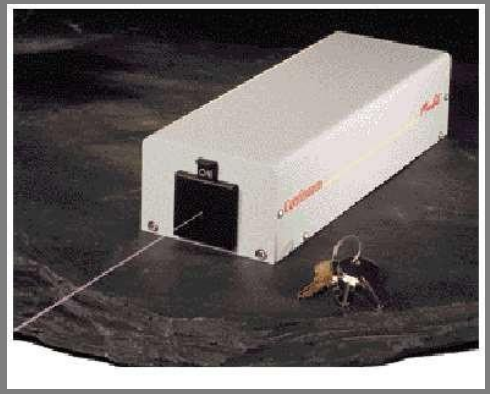
- Excimer Lasers
- Toxic gases - fluorine and chlorine
- UV light - invisible
- High voltage

SPECIFIC LASER OPERATION

- Helium-Neon (HeNe) Lasers
- Visible and near infrared spectrum -
  - Retinal damage
- High voltage
  - Electrical shock

SPECIFIC LASER OPERATION

- Neodymium-YAG (Nd:YAG) Lasers
- Spectrum ranges from UV to near infrared
  - Produce intense pulses
- Multi-wavelength lasers a problem for eye protection
- High-voltage
  - Electrical shock



SPECIFIC LASER OPERATION

- Carbon dioxide lasers
- Infrared spectrum
- Eye and skin hazards
- High-voltage hazards
  - Electrical shock

SPECIFIC LASER OPERATION

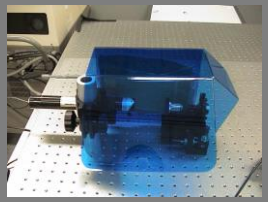
- Argon Ion Lasers
- Blue-green light
  - Can damage the retina and lens
- High voltage
  - Electrical shock

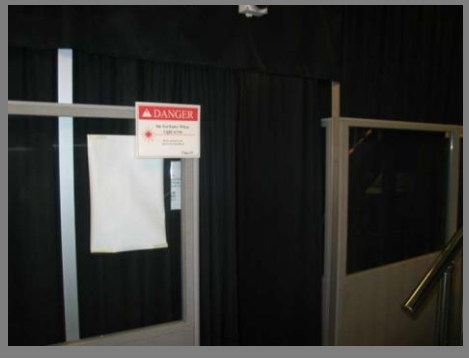
HAZARD CONTROL APPROACHES

- Engineering controls
- Administrative controls
- Personal protective equipment

ENGINEERING CONTROL FOR BEAM

- Enclose beam as much as possible
- Terminate beam at the end of the useful path
- Do not locate beam at eye level
- Barriers to beam - walls, partitions, curtains
- Area control - locked doors/interlocks





ENGINEERING CONTROL FOR DYE SYSTEMS

- Mix dyes in hood or glove box
- Eyewash/shower for chemical handling
- Assure system does not leak vapor or liquid
- Preparation work should be conducted in a well ventilated area

ENGINEERING CONTROL FOR GAS SYSTEMS

- Gas cabinets for cylinders of fluorine
- Local exhaust ventilation for fittings and the laser box
- Gas detection for fluorine - wired for the automatic valve shut off
- Evaluate oxygen deficiency potential risk from carbon dioxide, argon, and liquid nitrogen

ENGINEERING CONTROL FOR LGAC

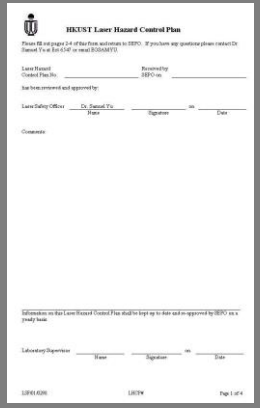
- Smoke evacuation equipment
- Local exhaust ventilation
  - Adequate air flow
  - Adequate capture velocity
  - Proper treatment of exhaust gas, e.g. HEPA filter

OTHER ENGINEERING CONTROLS

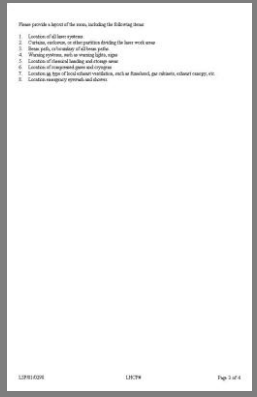
- X ray and non-ionizing radiation - Contact HSE Radiation Section
- Electrical hazards - Contact HSE Safety Engineer

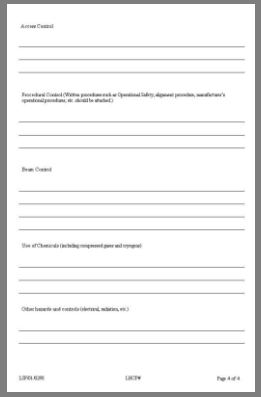
ADMINISTRATIVE CONTROLS

- Procedures - Laser Hazard Control Plan
  - Identify hazards and controls
- Safety precautions - Chapter 11 & other chapters of the HKUST(GZ) Safety Manual
  - For example, no jewelry or shiny tools, avoid beam viewing, electrical safety, etc.

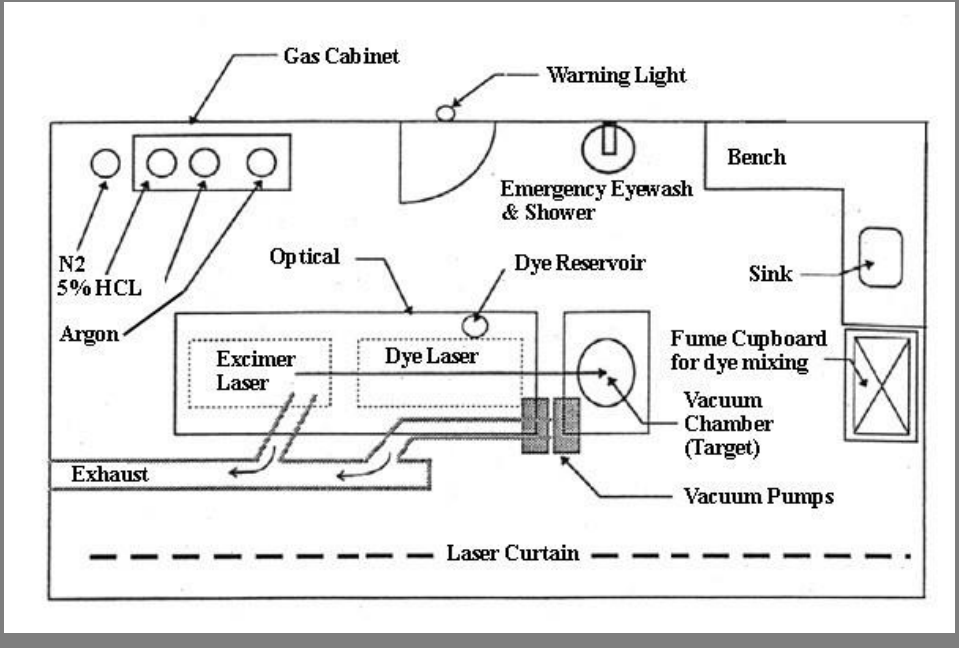

HKUST Laser Hazard Control Plan


Laser Hazard Control Plan





LASER HAZARD CONTROL PLAN LAYOUT

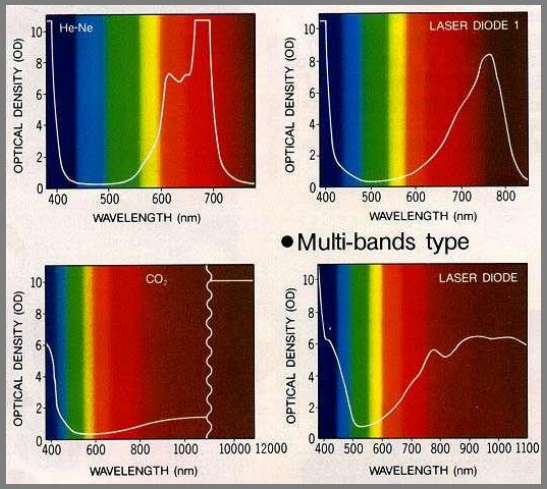


ADMINISTRATIVE CONTROLS

- Training - this class and supervisor guidance
- Warning lights and signs
- Medical surveillance - eye exam

PERSONAL PROTECTIVE EQUIPMENT: LASER GOGGLES

- Specific for wavelength(s) of beams and offer appropriate level of protection, i.e. not to exceed MPE
- No one pair of laser eyewear covers all wavelengths. Eyewear must be selected for specific wavelength used in the procedure.
- Laser eyewear must have the wavelength band it provides protection for and its optical density printed on the eyewear.
- Select eyewear by checking the wavelength coverage rather than color of the lens or a color coding system.



LASER GOGGLES: OPTICAL DENSITY (OD)

- Appropriate Optical density (OD) rates attenuation
  - OD is a measure of filtration, it is the opposite of transmission
  - OD is the log ratio of the incoming beam to what passes through the filter
  - The higher the OD number the less radiation passes through
  - The OD must be high enough to reduce the laser light to below MPE, yet not too high that it impairs vision
- Fit well
- Should always be worn when working with exposed beams
- Should never be used for direct beam viewing

OTHER PERSONAL PROTECTIVE EQUIPMENT

- Chemical goggles for dye mixing/cylinder changing
- Chemical-resistant gloves for dyes and solvents
- Surgical masks (“Laser plume masks”) or suitable respirator
- Protective clothing

ACCIDENTS AND CAUSES

- Improper handling of high voltage - 14 deaths in US
- Lack of eye protection
- Misaligned optics
- Equipment malfunction
- Improper service or replacement of parts
- Unanticipated eye exposure during alignment
- Toxic gas release

FACTORS

- Fatigue
- Hunger
- Attitude

ACCIDENT FACTS

- The most serious injuries are to the retina of the eye
- Retinal injury cases include those caused by laser reflections from specular surfaces such as soft drink bottles, as well as diffuse surfaces such as a chalk block, where a high-power laser was involved
- All cases of eye injury could have been prevented had the individuals worn proper eye protection

SUMMARY

- Beam hazards can be best controlled with engineering measures - enclose and stop the beam
- Wear correct wavelength laser safety goggles
- Make sure of engineering controls for toxic gases, dyes and solvents are in place

FURTHER INFORMATION

- 《激光产品的辐射安全、设备分类、要求和用户指南》（GB 7247.1-2012）
- 《激光安全标志》（GB 18217-2000）

THE END