Associated Non-Beam Hazards

While beam hazards are the most prominent laser hazards, other hazards pose equal or possibly greater risk of injury. These hazards must be addressed when conducting a risk assessment associated with the use and set up of lasers in a laboratory and in SOP's pertaining to use of the lasers. Non-beam hazards include electrical hazards, non beam radiation, toxic chemicals, explosion, harmful gasses and cryogenic fluids.

Electrical Hazards
Most lasers contain high-voltage and high current power supplies and often capacitors or capacitor banks that store very large amounts of electrical energy. In general, systems that permit access to components at such lethal levels must be interlocked; however, during maintenance and alignment procedures, such components often become exposed or accessible. Electrical equipment presents hazards such as: electrocution, arc flash, electrical burns and ignition of flammable materials. Electrical safety practices must be followed when working with high voltage sections of laser equipment or when in an area where work is being done on such areas. All components of a laser system must meet CSA or equivalent electrical certifications approved by the Electrical Safety Authority.

Electrical Safety Guidelines

- No one should work on lasers or power supplies unless qualified and approved to perform the specific tasks.
- Do not wear rings, watches, or other metallic apparel when working with electrical equipment.
- Do not handle electrical equipment when hands or feet are wet or when standing on a wet surface.
- Regard all floors as conductive and grounded.
- Be familiar with electrocution rescue procedure and emergency first aid.
- Prior to working with electrical equipment, de-energize the power source. Lock and tag out the disconnect switch in accordance Lockout/Tagout.
- Check that each capacitor is discharged, shorted, and grounded prior to working in the area of the capacitors.
- When possible, use shock preventing shields, power supply enclosures, and shielded leads in all experimental or temporary high voltage circuits.

Common Hazards Encountered When Working With Electrical Equipment

- Uncovered electrical terminals
- Improperly insulated electrical terminals
- Hidden power up/on warning lights
- Personnel lacking emergency training (UBC first aid information and contact can be found here)
- Buddy system not being practiced during maintenance and alignment work
- Non earth-grounded/improperly grounded laser equipment
- Excessive wires and cables on the floor that create fall/trip hazards

Laser Dyes and Solvents
Some lasers use dyes dissolved in a solvent as the laser medium. The dye is a fluorescent organic compound that may be toxic, mutagenic or carcinogenic. The solvent may be flammable and easily absorbed through the skin carrying the dye compound with it. Frequently, the most hazardous aspect of a laser operation is the mixing of chemicals that make up the laser dye. Therefore, care must be exercised in preparing the dye solutions, transferring the dye solutions into the laser cavity and in cleaning or maintaining the laser system. In addition, hazardous-waste-disposal concerns need to be addressed.

The safety control measures used with laser dye solutions include:

- Safety Data Sheet available and referenced
- use of less hazardous solvents when possible
- use of personal protective equipment (gloves, lab coat)
- use of fume hoods or glove boxes to prepare dye solutions
- containment of dye solution transfer pumps and reservoirs

Laser generated air contaminants (LGAC)
Air contaminants may be generated when certain Class 3b and Class 4 laser beams interact with matter or other components in the optical path of the laser beam. The types of contaminants that are generated vary from toxic (methyl methacrylate) and carcinogenic (benzene) chemical compounds to hazardous biological agents which require a biosafety permit to work with such as certain microorganisms and tissues. LGACs are usually generated when the beam irradiance exceeds 10^7 W/cm^2 due to the vaporizing effect of the laser radiation on the absorbing material at its surface. If LGAC production is suspected, control measures must be employed to ensure that the concentration of the LGAC is less than the occupational exposure limit specified in the Chemical Hazards Regulation. The control measures commonly employed include process isolation and exhaust ventilation.

Compressed and Toxic Gases
Hazardous gases maybe used in laser applications, i.e., excimer lasers (fluorine, hydrogen chloride). All compressed gases are physical hazards by virtue of the high pressure under which the gas is contained. If the gas is released in a rapid and uncontrolled fashion due to a rupture of the cylinder head, the cylinder can become a dangerous projectile causing damage and injury. If the gas is toxic (carbon monoxide) or corrosive (hydrogen chloride) it can burn tissue and cause pulmonary edema if allowed to leak into the work space. Even an inert gas such as argon or helium can cause asphyxiation if it leaks into an enclosed space and displaces oxygen. The risk assessment of laser laboratory setup should contain procedures for the safe handling of compressed gases, such as adequate ventilation, restraints for cylinders, use of gas cabinets where appropriate, proper tubing and fittings, etc.

Cryogenic Fluids
Cryogenic fluids are used in cooling systems of certain lasers, and can create hazards in some situations. As these materials evaporate, they can create oxygen deficient atmospheres and an asphyxiation hazard by replacing the oxygen in the air. Adequate ventilation must be provided. Cryogenic fluids are potentially explosive when ice collects in valves or connectors that are not specifically designed for use with cryogenic fluids. Condensation of oxygen in liquid nitrogen presents a serious explosion hazard if the

liquid oxygen comes in contact with any organic material. While the quantities of liquid nitrogen that may be used are usually small, protective clothing and face shields must be used to prevent freeze burns to the skin and eyes.

Explosion Hazards

High pressure arc lamps, filament lamps, and capacitors may explode if they fail during operation. These components are to be enclosed in a housing which will withstand the maximum explosive forces that may be produced. Laser targets and some optical components also may shatter if heat cannot be dissipated quickly enough. Consequently, care must be used to provide adequate mechanical shielding when exposing brittle materials to high intensity lasers.

Non Beam Radiation

Radiation is not only produced by the primary laser beam, but may also be produced by system components or the beam's interaction with materials. Such radiation can be in the form of X-rays, ultraviolet, visible, infrared, microwave or radiofrequency radiation. It can be generated by the laser power supply, discharge lamp or plasma tube. It can also be emitted from plasma produced by metal targets after the absorption of pulsed laser radiation in excess of 10^{12} Wcm^{-2}.

- **Radiofrequencies:** Some lasers contain radiofrequency (RF) excited components such as plasma tubes and Q switches. Unshielded and loosely tightened components may allow RF fields to leak from the device and expose staff.
- **Ionizing Radiation**: Ionizing radiation in the form of X-rays may be generated by electronic components of the laser system, including high voltage vacuum tubes of laser power supplies such as rectifiers, thyratrons, and electric discharge lasers. This ionizing radiation is produced by the process known as bremsstrahlung, or braking radiation. Power supplies which require more than 15 kilovolts may produce enough x-rays to be a health concern. X-rays can also be produced from laser-metal induced plasmas.
- **Ultraviolet and Visible Radiation:** Ultraviolet (UV) and visible radiation may be produced by laser discharge tubes, laser pump lamps and during laser-matter interactions. The levels produced may be an eye and skin hazard.
- **Plasma Emissions**: Interactions between very high power laser beams and target materials may in some cases produce plasmas which may contain blue light or UV emissions. When targets are heated to very high temperatures, as in laser welding and cutting, an intense bright light is emitted. This light often contains large amounts of short wavelength or blue light, which may cause conjunctivitis, photochemical damage to the retina, and/or erythema (sunburn-like reactions) in the skin.

Ergonomics

Ergonomic problems can arise from a laser operation by causing awkward unique arm and wrist positions. If such repetitive deviations occur for prolong periods of time, medical problems such as repetitive strain injuries may arise. At UBC, ergonomics consultation is available through https://hr.ubc.ca/health-and-wellbeing/ergonomics/lab-ergonomics.

Seismic Safety

To address the risk of personal injury and property damage posed by seismic activity all laser users need to review their laser setup for compliance with seismic safety guidelines. Examples would be fastening electronic racks to the floor or walls, and racks on casters having at least two locking wheels. When possible, heavy laser equipment should be bolted down.