

FREQUENTLY ASKED QUESTIONS LASERS

1. *Why Do We Have Classes of Lasers?*

To provide a basis for laser safety requirements, all lasers and laser systems and/or devices in the U.S. are classified into one of several classes. Corresponding labels are affixed to the laser or laser system. Understanding the laser classification is a fundamental prerequisite for any discussion of laser safety.

These laser classes are contained both in ANSI Z136.1 and in the Federal Laser Products, Performance Standard, 21 CFR 1040.10 and 1040.11. The first is followed by DOE and OSHA; the second is enforced by the Center for Devices and Radiological Health (CDRH), a part of the Food and Drug Administration (FDA). The classification for most lasers is provided by the manufacturer. For custom-built and modified lasers, Environmental Health and Safety can assist with classification.

The classification criteria for pulsed lasers are more complex, and are in the American National Standard for the Safe Use of Lasers, ANSI Z136.1, and Laser Products Performance Standard, 21 CFR 1040.10.

2. *What are the classes of lasers, and what do they mean?*

a. Class I Lasers

Class I lasers do not emit harmful levels of radiation and are, therefore, exempt from control measures. As a matter of good practice, unnecessary exposure to Class I laser light should be avoided.

b. Class II Lasers

Class II lasers emit accessible laser light in the visible region and are capable of creating eye damage through chronic exposure. In general, the human eye will blink within 0.25 second when exposed to Class II laser light. This blink reflex provides adequate protection. It is possible, however, to overcome the blink reflex and to stare into a Class II laser long enough to cause damage to the eye. Class II lasers have power levels less than 1 mW. Class II lasers are commonly found in alignment applications.

c. Class IIa Lasers

Class IIa lasers are special-purpose lasers not intended for viewing. Their power output is less than 1 mW. This class of lasers causes injury only when viewed directly for more than 1,000 seconds. The 1,000 seconds is spread over an 8 hour day, not continuous exposure. Many bar-code readers fall into this category.

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- d. **Class IIIa Lasers**
Class IIIa lasers and laser systems are normally not hazardous when viewed momentarily with the naked eye, but they pose severe eye hazards when viewed through optical instruments (e.g., microscopes and binoculars). Class IIIa lasers have power levels of 1-5 mW.
 - e. **Class IIIb Lasers**
Class IIIb laser light will cause injury upon direct viewing of the beam and specular reflections. The power output of Class IIIb lasers is 5-500 mW cw or less than 10 J/cm² for a 1/4-s pulsed system.
 - f. **Class IV Lasers**
Class IV lasers include all lasers with power levels greater than 500 mW cw or greater than 10 J/cm² for a 1/4-s pulsed system. They pose eye hazards, skin hazards, and fire hazards. Viewing of the beam and of specular reflections or exposure to diffuse reflections can cause eye and skin injuries.
3. ***What causes the most concern about lasers?***
- The most prominent safety concern with lasers is the possibility of eye damage from exposure to the laser beam, as outlined below. The nature of the damage and the threshold level at which each type of injury can occur depends on the beam parameters. These include wavelength, beam divergence, and exposure duration. For pulsed lasers, the parameters include pulse length, pulse repetition frequency, and pulse train characteristics.
- a. **Retina**
Laser light in the visible and near infrared (IR) region (400 nm–1400 nm) that enters the eye is focused on the retina. This can result in the following types of damage:
 - b. **Thermal Burn**
Normal focusing by the eye results in an irradiance amplification of roughly 100,000; therefore, a 1 mW/cm² beam entering the eye will result in a 100 W/cm² exposure at the retina. The most likely effect of intercepting a laser beam with the eye is a thermal burn which destroys the retinal tissue. Since retinal tissue does not regenerate, the damage is permanent. The ANSI MPE values are set below the threshold level for thermal burns.

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- c. **Acoustic Damage**
Laser pulses of a duration less than 10 microseconds induce a shock wave in the retinal tissue which causes a rupture of the tissue. This damage is permanent, as with a retinal burn. Acoustic damage is actually more destructive than a thermal burn. Acoustic damage usually affects a greater area of the retina, and the threshold energy for this effect is substantially lower. The ANSI MPE values are reduced for short laser pulses to protect against this effect.
- d. **Photochemical Damage**
Light below 400 nm is not focused on the retina. The light can be laser output, ultraviolet (UV) from the pump light, or blue light from a target interaction. The effect is cumulative over a period of days. The ANSI standard is designed to account only for exposure to the laser light. If UV light from a pump light or blue light from a target interaction is emitted, additional precautions must be taken.
- e. **Other Eye/Skin Hazards**
When UV or IR laser light enters the eye, much of the light is absorbed in the lens. Depending on the level of exposure, this may cause immediate thermal burns or the development of cataracts over a period of years.

The cornea and the conjunctiva tissue surrounding the eye can also be damaged by exposure to laser light. Damage to the cornea and conjunctiva tissue usually occurs at greater power levels than damage to the retina; therefore, these issues only become a concern for those wavelengths that do not penetrate to the retina (i.e., UV and IR radiation). Since the amplification by the lens is not involved, the injuries can also be caused by diffuse and noncoherent light.

Skin can suffer thermal burns and photochemical changes from laser exposure. These effects are almost entirely independent of the coherent nature of the laser light, but are aggravated by the high power density of lasers.

4. *Apart from laser beam what other laser operational concerns do we have?*

While beam hazards are the most prominent laser hazards, other hazards pose equal or possibly greater risk of injury or death.

- a. **Electrical Hazards**
Most lasers contain high-voltage power supplies and often large capacitors or capacitor banks that store lethal 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. This has caused numerous serious and some fatal shocks at other research facilities.

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b. 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.
- When working with high voltages, 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 with WVU Lockout/Tagout policy.
- 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.

c. Common Hazards Encountered When Working With Electrical Equipment

- Uncovered electrical terminals.
- Improperly insulated electrical terminals.
- Hidden power up/on warning lights.
- Lack of personnel training in CPR (this and first aid training is offered at the Lab).
- 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.

5. *What are laser Dyes?*

Laser dyes are often toxic and/or carcinogenic chemicals dissolved in flammable solvents. This creates the potential for personnel exposures above permissible limits, fires, and chemical spills. Frequently, the most hazardous aspect of a laser operation is the mixing of chemicals that make up the laser dye. In addition, hazardous-waste-disposal concerns need to be addressed.

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6. ***How about compressed and toxic gases as they relate to laser operation?***
Hazardous gases maybe used in laser applications, i.e., excimer lasers (fluorine, hydrogen chloride). The AHD should contain references for the safe handling of compressed gases, such as seminic restraints, use of gas cabinets, proper tubing and fittings.
7. ***How about cryogenic fluids as they relate to laser operation?***
Cryogenic fluids are used in cooling systems of certain lasers, and can create hazards 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.
8. ***How about the radiofrequencies (RF) hazard?***
Some lasers contain RF excited components as plasma tubes and Q switches. Unshielded and loosely tightened components may allow RF fields to leak from the device and expose staff.
9. ***Is there potential for ergonomic problems in certain laser operations?***
Yes. 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.