LASER SAFTEY

J.A. Rosa Construction, LLC

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CHA[TER 18 – LASER SAFETY

18.1 Introduction

This chapter provides guidance for the safe use of lasers and laser systems. It is derived from ANSI Z136.1, Standard for the Safe Use of Lasers, prescribed by the Department of Energy and OSHA regulations. The ANSI Standard establishes a hazard classification scheme based on the ability of the laser beam to cause biological damage to the eye or skin. This scheme is used to place each laser into one of four classes; each laser must meet the laser safety requirements specified for its class.

Definitions and Terms

Below is a comprehensive list of terms related to lasers, encompassing their components, properties, types, applications, and safety considerations:

I. Fundamental concepts and components
- LASER: Stands for Light Amplification by Stimulated Emission of Radiation.
- Stimulated Emission: The core principle where an incoming photon triggers an excited atom to emit an identical photon, amplifying light.
- Gain Medium (Active Medium): The material (solid, liquid, gas, or semiconductor) that amplifies light through stimulated emission.
- Energy Source (Pump): Provides the energy to excite atoms within the gain medium.
- Optical Resonator (Optical Cavity): Consists of mirrors that reflect light back and forth through the gain medium, creating a coherent beam.

II. Properties of laser light
- Monochromaticity: Laser light consists of a single wavelength (or a very narrow range of wavelengths).
- Directionality (Collimation): The laser beam is highly focused and travels in one direction with minimal divergence (spreading).
- Wavelength (λ): The distance between repeating units of a propagating wave, which decides the color of the laser light and how it interacts with materials.

III. Types of lasers
- Solid-State Lasers: Use solid materials like crystals (e.g., Ruby, Nd:YAG) as the gain medium.
- Gas Lasers: Use gases or gas mixtures (e.g., Helium-Neon, Carbon Dioxide, Argon) as the gain medium.
- Semiconductor Lasers (Diode Lasers): Employ semiconductor materials (e.g., silicon) where laser action arises from electron movement across diode junctions.

IV. Laser output modes
- Continuous Wave (CW): Emits a continuous beam of light.

V. Laser safety terms

- Laser Classes: A system (e.g., Class 1, Class 2, Class 3R, Class 3B, Class 4) that classifies lasers based on their potential hazard levels to the eyes and skin.
- Class 1: There are no control measures or warning labels needed, but needless exposures to the eye should be avoided as a matter of good practice.
- Class 2: A suitable warning label must be affixed to the laser housing or control panel and have protective housing.
- Class 3: Class 3 lasers are divided into two groups, Class 3R and Class 3B. Class 3R lasers are those which have an accessible output power between 1 and 5 times the lowest appropriate Class 3 exposure level and which do not exceed the appropriate maximum permissible exposure limit. Class 3R lasers are more powerful and require added control measures but are not used in field operations as a leveling apparatus.
- Maximum Permissible Exposure (MPE): The maximum level of laser radiation a person can be exposed to without hazardous effects.
- The Nominal Ocular Hazard Distance (NOHD) is the distance from a laser source at which the irradiance (power per unit area) of the laser beam drops to the Maximum Permissible Exposure (MPE) level, a limit for safe direct eye exposure. At distances shorter than the NOHD, the beam's intensity is too high and poses a risk of eye injury, while at distances beyond the NOHD, the beam is considered safe for unaided viewing.
- Nominal Hazard Zone (NHZ): The area where the laser radiation exceeds the MPE.
- Laser Protective Eyewear (LPE): Special glasses or goggles designed to protect the eyes from specific laser wavelengths.
- Optical Density (OD): A measure of the ability of protective eyewear or filters to block laser light.
- Controlled Area: An area with restricted access and supervised activity to protect against laser hazards.
- Aversion Response: Natural protective actions like blinking or turning away from bright light.
- Intrabeam Viewing: Directly looking into the laser beam.
- Specular Reflection: Mirror-like reflection of a laser beam.
- Diffuse Reflection: Scattering of laser light off a rough surface.

Most laser products are required by law to have a label listing the Class. It will be listed either in Arabic numerals (1 2, 3R, 3B, 4) or in Roman numerals (I, II, IIIa, IIIb, IV).

Class 1 lasers are considered Safe, even for long term intentional viewing. Class I usually applies when the laser is enclosed inside a device (ex: CD or DVD player) with no human access to the light. Safe for unaided eye exposure. Safe for unintentional exposure less than 1/4 second. Do not stare into beam. Safe for unintentional (< 1/4 sec) unaided eye exposure. Unintentional or accidental exposure to direct or reflected beam has a minimal risk.

Avoid intentional exposure to direct or reflected beam. Maximum or typical **N**ominal

Ocular **H**azard **D**istance (for 1 milliradian beam, exposure time less than 1/4 second) is **23 feet (7 m)**.

For a 1/4 second exposure to accessible visible light beams, Class 1 limits are the same as Class 2, and such lasers are usually labeled as Class 2 and are suitable for most general-purpose laser levels and simple alignment tasks,

There are no control measures or warning labels needed, but needless exposures to the eye should be avoided as a matter of good practice.

Class 2 lasers are considered safe for normal operation. Class 2 lasers' output power is below 1 milliwatt. All Class 2 lasers emit visible light only.

For a 0.99 mW Class 2 laser with a less-tight beam that spreads out faster (1 milliradian). Like Class 1, the NOHD is **23 feet (7 m)**. This divergence is more typical of consumer lasers. A Class 2 laser is relatively weak. It normally would not harm an eye unless a person deliberately stared into the beam. Laser protective eyewear is normally not necessary. The natural blink reflex provides protection from accidental, brief viewing. A Class 2 laser is not a skin or materials burn hazard. A suitable warning label must be affixed to the laser housing or control panel and have protective housing.

However, even a Class 2 laser can be a distraction, glare or flash blindness hazard for pilots and drivers. NEVER aim any laser towards a plane or vehicle that is in motion. This is unsafe and illegal.

Class 3 lasers are divided into two groups, Class 3R and Class 3B. Class 3R lasers are those which have an accessible output power between 1 and 5 times the lowest appropriate Class 3 exposure level and which do not exceed the appropriate maximum permissible exposure limit. Class 3R lasers are more powerful and require added control measures but are not used in field operations as a leveling apparatus.

Class 3R lasers are used for more detailed alignment and leveling tasks that require a brighter, more visible beam, especially outdoors. There is a moderate hazard potential for accidental exposure. It can potentially cause eye damage if viewed directly for extended periods, but safe when managed carefully**.** For visible-light lasers, Class 3R lasers' output power is between 1 and 4.99 milliwatts.

A Class 3R laser is low powered. It normally would not harm eyes during a momentary exposure of less than ¼ second. This is within the aversion response, where a person turns away and/or blinks to avoid bright light

Do not deliberately look or stare into the laser beam. Laser protective eyewear is normally not necessary. A Class 3R laser is not a skin or materials burn hazard.

The NOHD for the more powerful Class 3R visible-beam laser (4.99 mW) with a tight beam (0.5 milliradian divergence) is **104 ft (32 m)**.

Class 3B lasers are hazardous for eye exposure. They can heat skin and materials but are not considered a burn hazard. For visible-light lasers, Class 3B lasers' output power is between 5 and 499 milliwatts.

Class 3B visible-beam lasers are medium-powered, from 5 to 499 milliwatts and **can cause eye injury.** The more powerful the laser, the greater the chance of injury.

Remember that reflections off mirrors, glass, and shiny surfaces can be just as hazardous as the direct beam. **Avoid reflected Class 3B beams the same way you would avoid the direct beam.**

- The Nominal Ocular Hazard Distance (NOHD) for a lower-powered 50 mW Class 3B visible-beam laser with a tight beam (0.5 milliradian divergence) is **330 ft (100 m)**.
- The NOHD for the most powerful 499 mW Class 3B visible-beam laser with a tight beam is **1,050 ft (320 m)**.

If you are closer than the NOHD distance to the laser, there is a possibility of retinal damage if the direct or reflected beam enters your eye.

Class 4 lasers are hazardous for eye exposure. They also can burn skin and materials, especially at close range. They should be used with extreme care.

For visible-light lasers, Class 4 lasers have an output power of 500 milliwatts and above. There is no upper limit for Class 4 -- this is the most hazardous laser classification.

- Looking at the laser dot from a 1,000-milliwatt (1 Watt) Class 4 blue (445 nm) laser beam for more than 1 minute is an eye hazard within **1.5 ft (44 cm)** of the laser.
- Looking at the laser dot from a 10,000-milliwatt (10 Watt) Class 4 blue (445 nm) laser beam for more than 1 minute is an eye hazard within **4.5 ft (1.4 m)** of the laser. Even just for 10 seconds, viewing the laser dot is a hazard within **1.8 ft (0.6 m).**

Use of laser protective eyewear when using a Class 3B or Class 4 laser.

18.2 Laser Safety Duties of Safety Manager

The Safety Manager (SM) provides consulting on laser hazards, safety controls, and training programs. If he/she considers that the laser hazard controls are inadequate, the SM can suspend, restrict, or stop the operation of a laser or laser system.
The SM keeps the necessary records required regulations. In addition, the Safety Manager.

- Approves all protective equipment used for the control of laser hazards.
- Provides an adequate stock of eye protective equipment.
- Inspect all laser areas as often as they are considered necessary.
- Ensure that corrective action is taken where needed.
- Reviews for new installations
- Ensure that the hazard control measures are adequate.
- Investigates any accident resulting from a laser operation
- Initiates proper action.
- Provides an adequate stock of warning signs , and
- Help supervisors in developing training programs.

18.3 Additional Duties for the Safety Manager

The Safety Manager also prepares an Operational Safety Procedure for Class 3 and Class 4 lasers and laser systems and ensures that they are provided to users of such lasers. Ensures that personnel using Class 3 and Class 4 lasers undergo a laser eye examination (a) prior to participation in laser work and (b) at once after a suspected eye injury. Performs all scheduling of personnel for the laser eye examination. Notify the proper Medical Services provider immediately of any known or suspected accident. Assists in obtaining the proper medical attention for any employee involved in a laser accident.

18.4 Employee Responsibilities

Employees who work near a laser must receive proper training and follow the safety regulations prescribed by their supervisor. Employee must notify the supervisor immediately of any known or suspected accident involving a laser. (If the supervisor is not available, the employee must immediately notify the applicable Medical Services provider or dial 911 for emergencies.)

18.5 User Responsibilities

It is the responsibility of the user to notify the Rosa Safety Manager whenever the decision is made to fabricate, purchase or otherwise acquire a laser. This will facilitate the proper functioning of Rosa’s laser safety program and allow the user to be informed about the safety considerations proper to the laser he is buying, prior to its actual use. To help ensure that oversights do not occur, the Purchasing Department has been asked to refer each requisition for a laser to SM to initial before an order is placed.

18.6 OPS for Class 3B and 4 Lasers

Each Class 3B or Class 4 laser or laser system must have an **Operational Safety Procedure (OSP)** located near the unit. It must have at least the following information:

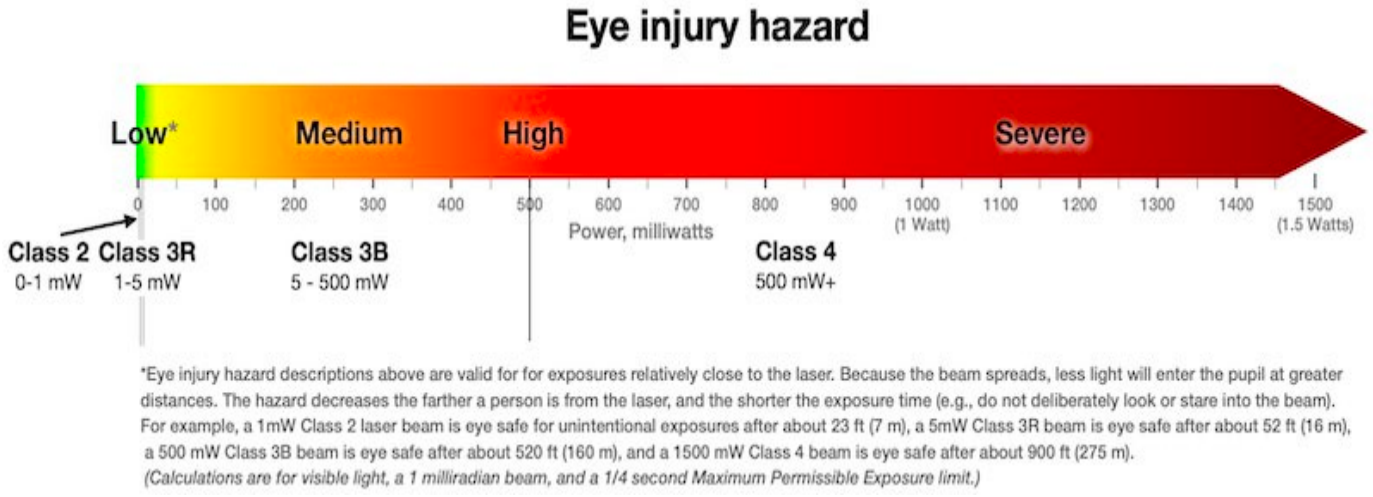
- Name of the laser system supervisor
- List of authorized users
- General description of the laser or laser system
- Specific safety control measures used
- Specific alignment procedures used, if applicable
- Eye protection needed, if applicable and
- Emergency instructions.

Most laser levels used in construction are Class 2 or 3R lasers therefore an Operational Safety Procedure will only be prepared when the need is called for.

18.7 Injury Potential Evaluation

Injury potential from exposure to a laser beam is the basis of the following hazard classification scheme: A Class 1 laser is one that is incapable of producing damaging radiation levels and is, therefore, exempt from any control measures.

As a matter of good practice, any needless direct exposure of the eye should be avoided, regardless of class. A Class 2 laser emits accessible, visible radiation at levels where damage from chronic exposure is possible. Class 2 and 3B lasers must have a caution label affixed to the external surface of the device. A Class 3R laser requires control measures to prevent viewing of the direct beam since biological damage to human tissue is possible from acute exposure. Class 3 lasers are subdivided into two classes, Class 3B and Class 3R. A Class 4 laser requires the use of controls that prevent exposure of the eye and skin to the direct and diffusely reflected beams.



Most laser levels used in construction are Class 2 or 3R lasers which are low powered. These are considered safe if accidentally viewed because the normal blinking reflex that protects the eyes helps prevent injury.

18.8 Control Measures

Control measures are applied after the laser has been properly classified. Most laser levels used in construction are Class 2 or 3R lasers which are low powered. These are considered safe if accidentally viewed because the normal blinking reflex that protects the eyes helps prevent injury. Control measures described below are limited to class 2 and 3R:

1. Physical (enclosures, interlocks, beam stops, etc.)
2. Protective equipment (goggles, clothing, etc.)
3. Warning devices (signs, lights, labels, etc.)
4. Physical procedures are always the preferred method for controlling access.

18.9 Laser Housing

The protective housing in any Class 2, Class 3, or Class 4 laser system must limit the maximum accessible laser radiation. The control measures appropriate to the classification apply when the laser is in normal operation.

18.10 Additional Controls

Since infrared and ultraviolet radiations are invisible, particular care must be taken when using these laser systems. Thus, in addition to the control measures that apply to the laser hazard classification, the following controls also apply: Infrared lasers (>0.7 mu m): The beam from a Class 3R laser should be terminated by a highly absorbent, non-specular backstop.

18.11 Protective Eyewear

ANSI Z136. 1, states laser safety eyewear must provide sufficient optical density to reduce the power of a laser to be equal or less than the Maximum Permissible Exposure levels (MPE). Indelibly printed on the laser safety glasses are two sets of numbers: Optical Density (OD) and LB-Rating, which are both used to indicate the level of protection provided for specific wavelength ranges. The OD numbers can be used to determine if the glasses meet the ANSI Z136 standards of laser safety.

Laser protective eye wear must be worn whenever operational conditions may result in a potential eye hazard. All protective eye wear must be clearly labeled with the optical density at the right laser wavelength(s).

18.12 Signs

All signs must be displayed at entrances to control laser areas. Place any pertinent precautionary instructions or protective actions which may be needed.

18.13 Medical Exams

Medical surveillance of personnel working in laser environments using Class 2 or 3B is not required.