Laser Safety

MASC Regional Safety Office
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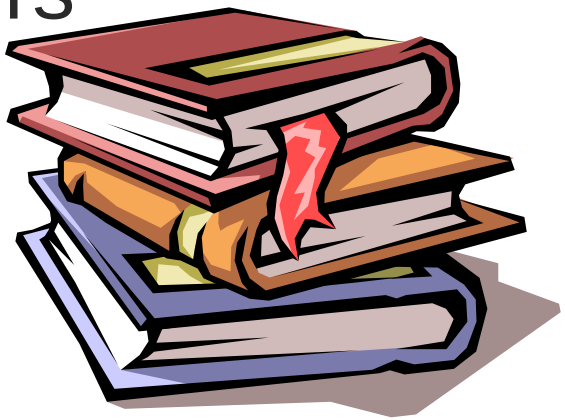
Laser Safety References

ANSI Z136.1 (2000) Standard

American National Standards Institute, Inc.

Safe Use of Lasers



Additional References

Z136.1 is main document to other standards regarding lasers

ANSI Z136.2-1997 for the *Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources*

***ANSI* Z136.3-1996** for the *Safe Use of Lasers in Health Care Facilities*

ANSI Z136.5-2000 for the *Safe Use of Lasers in Educational Institutions*

ANSI Z136.6-2000 for the *Safe use of Lasers Outside*

Laser Classification

- **Class 1** (Exempt)
  - Incapable of producing damaging radiation levels
  - Laser beam is enclosed
- **Class 2** (Low Power)
  - Visible (400-700 nm)
  - Eye protection is aversion response
  - CW upper limit is 1 mW
  - Applies only to visible lasers

Laser Classification

- **Class 3** (Medium Power)
  - Divided into two subclasses, 3a and 3b (changing to 3R)
  - Hazardous under direct and specular reflection viewing
  - Diffuse reflection usually not hazardous
  - Normally not a fire hazard
  - CW upper limit is 0.5 W (this is set by the fire hazard it presents)

Laser Classification

- **Class 4** (High Power)
  - Hazardous to eye and skin from direct viewing and diffuse reflection
  - Fire hazard
  - May produce laser generated air contaminants (LGAC)
  - May produce hazardous plasma radiation

New Classes

- **Class 1 & 1M:**

  -Class 1 eye safe even with optical aids

  -Class 1M eye safe except with optical aids
- **Class 2 & 2M:**

  -Class 2 safe for momentary viewing

  -Class 2M safe for momentary viewing w/o optical aids
- **Transitional-zone Class 3 lasers in Class 3R – "Reduced Requirements" (formerly 3a)**

New Laser Safety Classification Scheme

- Despite the appearance of major changes, the actual impact on existing products will be minimal:

  -All current Class 1 are now Classes 1 and 1M

  -Most current Class 2 are now Class 2 (or 2M if a highly diverging beam, e.g., a diode laser)

  -All current US Class 3A (IEC 3B*) “Danger” laser pointers are a new Class 3R

  Class 3a expanded-beam lasers are rare and are now in Class 1M or 2M
- Refer to Appendix H in ANSI Z136.1-2000

New Class 1M Laser Products

- “EYE SAFE” for the unaided eye and with no added optical elements

New Class 1M Laser Products

- Safe under every “reasonably foreseeable” viewing condition without optical aids
- Requirements: Only a label (optional for manufacturer) or user information that the product is Class 1M in accordance with the standard and suggested warning statement, as “Do not view with hand magnifiers or microscopes” for a diverging beam, or “Do not view with telescopes/binoculars” for collimated beams.

New Class 2M Laser Products

- AEL + AEL for Class 1 for 0.25s exposure
- Limited to “visible” (400 – 700-nm) lasers
- Safe to view by the unaided eye for 0.25 s due to the eye’s natural aversion response
- Unsafe under viewing conditions with optical aids
- Requirements: Only aperture and class labels or user information that the product is Class 2M in accordance with the standard.

New Class 3R Laser Products

- Laser product marginally unsafe for intrabeam viewing
- AEL of 5X the AEL of Class 1 or 2 as appl.
- Same basic definition as the old IEC Class 3B* and ANSI Class 3A non-expanded-beam lasers with “Danger” label

New Class 3R Laser Products

- Eliminates current differences between US and IEC definitions of Class 3A and 3B
- Requirements: eliminates most of 3B requirements
- No changes in manufacturing requirements

Retinal Injury

- Photo disruption of retina – Retinal hemorrhage from Q-switched laser pulse.
- Visual Effect: Scotoma – Blind spot in field of vision.

Skin Injury

Photochemical and Thermal Burns

- Thermal Skin Burns – Rare; normally requires high exposure dose of at least several J/cm²; most common from CO2, 10.6 µm laser exposure. First degree (erythema), second degree (blistering), and third degree (charring) burns are possible dependent upon exposure dose.

Skin Injury

- Ultraviolet “Sunburn” – Erythema (reddening) from UV-B and UV-C radiant energy.
- Ultraviolet Radiation Delayed Effects – Skin Cancer and accelerated skin aging (wrinkles, etc.).

Summarizing Skin Hazards

From a safety standpoint, skin effects have usually been considered of secondary importance. However, with the more widespread use of lasers emitting in the ultraviolet spectral region as well as higher power lasers, skin effects have assumed greater importance.

Maximum Permissible Exposure (MPE)

- Definition

  - Maximum level of exposure to laser radiation without hazardous effect or adverse biological changes in the eye or skin

- Used to determine

  - Nominal hazard zone (NHZ)

  - Optical density (OD)

  - Accessible Emission Limit (AEL)

Maximum Permissible Exposure (MPE)

- Eye exposure generally lower than skin
- Depends on the wavelength, exposure duration and other factors
- Also know as the Occupation Exposure Limit (EL), Threshold Limit Value (TLV)

Non-Beam Hazards

- A class of hazards that result from factors other than direct human exposure to a laser beam.
- Other terms include

  - Ancillary hazards

  -Collateral hazards

  -Associated hazards

  -Special consideration

Non-Beam Hazard Categories

- Chemical
- Biological
- Physical
- Other

Chemical Agents: (LGAC's)
Laser Generated Air Contaminants

- Gas/vapor – state materials
- Aerosols
  - Viable
  - Organic
  - Metal Oxides

- See Table F1 (b), pp. 153-155, ANSI Z16.1-2000

Control Methods: Chemical Agents

- Substitution of less toxic material (s)
- Source isolation and engineering controls
- Personal protective equipment

Biological Agents

- Cells
- Microorganisms
- Laser-generated air contaminants (LGAC's)

Physical Agents

- Plasma Radiation
- Collateral Radiation
- Electricity
- Noise
- Fire
- Explosions

Electrical Hazards

- Shock
- Electrocution
- Fire
- Not unique to lasers

Electrical Hazards Controls

- Don’t wear highly conductive items on hands or arms
- Follow the one-hand rule; eliminate arm-to-arm pathway
- Never do electrical work alone, your “buddy” must know first aid/CPR
- Follow all safety procedures, including lockout/tagout per 29 CFR 1910.147

Fire Hazards

- Enclosure materials
- Electrical components
- Target materials
- Laser Gases
- LGAC
- Laser beam (Class IV)

Other Non-Beam Hazards

- Explosion Hazards

  - May exist within laser, due to:
    - high pressure arc lamps
    - filament lamps
    - capacitor banks
  - May exist outside the laser, due to:
    - the target (flying particles)
    - elements of the optical train, which may overheat

Control Measures

- Control Measures are based upon hazard evaluation and classification

- 3 aspects of laser application influence hazard evaluation

  - The laser's capability of injuring personnel

  - The environment in which the laser is used

  - The personnel who may use or be exposed to the laser radiation

Capability of Injuring Personnel

- Determined by the class of laser
- All lasers must be classified by manufacturer
- Or by LSO using Section 3 of Z136.1
- FLPPS requires labeling of all lasers in Class II and above

Laser Controlled Areas

- Class 3b laser controlled area
- Class 4 laser controlled area
- Temporary laser controlled area

Laser Safety Eye Protection

- Filters

  - absorptive – dyes absorb laser radiation
  - reflective – coatings (e.g., dielectrics) reflect laser radiation
  - combinations may provide multi-wavelength protection

- Glass

  - scratch resistant
  - stability against bleaching
  - ease for prescription lenses
  - higher optical quality
  - good visual transmittance

Laser Safety Eye Protection

- Plastic
  - low weight
  - break resistant

- Storage
  - keep clean
  - ease of identification
  - entryway

Protective Eyewear: Things Not to Do

- Leave on the optics bench
- Stored by hanging by the elastic strap

  - Stretches (deforms) the strap

  - Allows dust to collect within

Rules to (safely) lase by

- Purchase and use certified Class 1 laser products when possible
- Enclose as much of the beam as possible
- Don’t direct beam toward doors/windows
- Don’t locate beam at eye level
- Terminate beams or reflections with fire-resistant beam stops

Rules to (safely) lase by

- Utilize surfaces that scatter radiation and minimize specular reflection
- Locate controls so operator is not exposed to beam and non-beam hazards
- Make sure warning/indicator lights can be seen through protective filters
- View application remotely

Questions

- If you have any questions or concerns please contact the MASC Regional Safety Office at (303) 497-3912 or Rhonda.S.Carpenter@noaa.gov.