# Laser Radiation

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## Introduction

Exposure to lasers can be hazardous, resulting in permanent and disabling eye injuries, skin damage, and harmful effects to other biological systems. Since May 1996, the Navy's Laser Safety Review Board (LSRB) has provided authoritative safety reviews and assistance for acquisition, development, and deployment of over 100 laser systems, exercises, and deployment protocols.

LSRB's early involvement in the acquisition process helped acquisition program managers to minimize their programs' risks, including unacceptable system performance, delays in testing, and cost and schedule slippage.

The success of the Navy's Laser Radiation Safety Program is illustrated by the absence of a single mishap or injury attributed to laser systems or misguided laser munitions during the Gulf War conflict, when tens of thousands of sophisticated laser systems were used.


Aboard USS Kitty Hawk (CV 63), an Aviation Electronics Technician 3rd Class disassembles the Forward Looking Infrared (FLIR) pod, which uses lasers to guide laser-guided bombs from F/A-18 "Hornets" to their targets. US Navy photo by Photographer's Mate 3rd Class Lindsay Minturn.

The Department of the Navy's (DON) policy (OPNAVINST 5100.19 Series and OPNAVINST 5100.23 Series) is to identify and control Laser Radiation Hazards early during the system design and development process. This section of the Acquisition Safety website will concentrate on the safety and health challenges of laser radiation in the shipboard environment and the Navy's success in designing systems that eliminate risk. [See the Resources Section for more information on DON policy and instruction on Laser Radiation].

## Background

Lasers are designed to operate at various wavelengths in the ultraviolet, visible portions of the electromagnetic spectrum, and are used in various military and scientific applications. Laser-guided weapons and laser target identification devices are typical military applications of lasers found aboard Navy ships. The Navy has adopted the American National Standards Institute's (ANSI) Z136.1 laser hazards classifications system, which provides a practical means for determining safety requirements appropriate for different types of lasers. There are four laser hazard classifications, and there are two types of laser hazards - laser beam hazards and non-beam laser hazards:

Sailors assigned to the Weapons Department attach a laser guidance unit to a BLU-111 500-pound general-purpose bomb in an ammunition magazine aboard USS Kitty Hawk (CV 63).

## Challenges

### Common Causes of Laser Accidents

According to American National Standard Institute (ANSI) Z136.1-2000, *Safe Use of Lasers*, ninety-five percent of laser accidents occur due to the following:

- Unanticipated eye exposure during alignment of laser beams.
- Misaligned optics and upwardly directed beams.
- Available laser eye protection not used.

The Department of Energy's (DOE) Office of Environment, Safety and Health published a Special Operations Report: Laser Safety, February 2005, which examined the root causes of seven DOE laser incidents occurring between 2001 and 2005. This report identified the following as the root causes of the mishaps:

- Inadequate training: Lack of training and an inadequate level of understanding of hazards and controls were factors in most laser incidents analyzed. In addition, there was an inadequate level of knowledge displayed by those required to oversee laser operations and supervise laser users. Personnel were not familiar with or did not comply with the basic safety recommendations of ANSI Z136.1-2000.
- Inadequate Laser Safety Officer (LSO) conduct: The LSO's role and authority were not clearly defined. The LSO did not have the authority to grant operational authorization and had not adequately assessed the hazards and controls of the laser operation.

- Inadequate Internal Oversight: Infrequent or inadequate line management oversight of laser operations was a contributing factor to laser exposures.
- Failure to Wear Personal Protective Equipment (PPE): Personnel either did not fully comprehend the need for protective eyewear or thought that they had properly controlled the laser hazards in such a way that protective eyewear was not necessary.

While laser injuries associated with military operations aboard Navy ships have been rare, lessons learned from the above causes of laser mishaps can help the Navy to design systems that protect Sailors from laser mishaps.

## Recommendations

### Laser Safety Design and Review Process

DON policy is to identify and control laser radiation hazards early during design and development as a matter of military necessity. OPNAV Instruction 5100.27A/Marine Corps Order 5104.1B, Navy Laser Hazards Control Program, provides a "*Laser Safety Design Requirement Checklist*" for the designer, procuring activity, or personnel responsible for laser safety to ensure they comply with the laser safety design requirements for military lasers and associated support equipment. This comprehensive checklist compiled from MIL-STD-1425 must be used by manufacturers and commands when submitting requests for a laser evaluation.

The Navy's LSRB provides authoritative safety reviews and assistance for acquisition, development, and deployment of laser systems, exercises, and deployment protocols.

### Laser Engineering Controls

The implementation of engineering controls as the primary method of safety in the acquisition design process will reduce the risk of laser-related mishaps as well as reducing manpower and training requirements for operating laser systems. These measures will in turn reduce the life-cycle cost of the acquisition program.

Room size protective laser housing enclosure

Engineering controls are design features applied to the laser or laser environment. They restrict exposure or reduce irradiance. Some engineering controls include:

- **Protective Housing, Interlocks:** A protective housing is a physical barrier sufficient to contain the beam and laser radiation from exiting the laser system so that the maximum

permissible exposure (MPE) is not exceeded on the outside surface. Protective housings or enclosures must have an interlock system, which is activated when the protective housing is opened during operation and maintenance. For example, opening a door to a protective housing should de-energize the source, and it should be possible to reenergize the source only through a specific action such as pressing a switch.


RQ-8A Fire Scout Vertical Takeoff and Landing Tactical Unmanned Aerial Vehicle that can autonomously take off and land from any aviation-capable warship and at unprepared landing zones utilizes baseline payload that includes a laser rangefinder /designator to find, identify, track, and designate targets, provide targeting data, employ precision weapons, and perform battle damage assessment. U.S. Navy photo by Photographer's Mate 2nd Class Daniel J. McLain

- **Remote Firing and Monitoring:** A remote firing and monitoring console allows the laser to be operated from a remote location, removing the operator from the hazard.

- **Barriers, Beam Stops/Beam Attenuators, and Enclosures:** Beam barriers, stops, and enclosures are used to prevent beam propagation outside of the controlled access area in excess of the MPE. The beam path should be enclosed as much as possible. Laser blocking curtains and screens are routinely used as laser containment systems.
- **Viewing Windows:** Viewing windows and/or display screens incorporate suitable means (such as interlocks, filters, and attenuators) to maintain the laser radiation at the viewing position at or below the applicable MPE for all conditions of operation and maintenance.
- **Service Access Panels:** These are portions of the protective housing and are intended to be removed only by service personnel. They permit direct access to laser radiation. They must either: 1) be interlocked, or 2) require a tool for removal and must have an appropriate warning label.
- **Master Switches:** A master switch may be a key or coded access (such as a computer code) that is required to operate the laser.
- **Laser Warning Systems**: An alarm/buzzer, warning light, or a verbal "countdown" command can be used during activation or start-up of the laser. A light system will also illuminate when the interlock system is operational: green (safe), yellow (caution), and red (laser in use).

**Laser Administrative Controls**

- **Access Restriction:** Access controls are required for Class 3b and Class 4 lasers to prevent unauthorized personnel from entering the area when the laser is in use.

Doors must be kept closed when the laser is in operation and locked when the laser is left unattended. A door interlocked with the laser shutter may be required.

- **Controlled Area:** Area control measures are used to minimize laser radiation hazards for Class 3b and Class 4 lasers. The area must be posted with the appropriate signage and include a lighted sign at the doorways indicating the "on" status of a laser system. Only authorized personnel who have been appropriately trained are allowed to operate the laser.

**Laser System Safety Officer (LSSO) Roles, Responsibilities, and Training Requirements**

OPNAV Instruction 5100.27A/Marine Corps Order 5104.1B clearly defines the role, responsibilities, and training requirements for a Navy Laser System Safety Officer (LSSO). The commanding officer of a Navy activity that uses Class 3b or Class 4 lasers, or systems incorporating any Class 3b or Class 4 lasers, designates an individual by name and code as the LSSO. Responsibilities and duties of the LSSO are formally documented to ensure that lasers are operated safely per the OPNAV Instruction. The Instruction states that the LSSO should have direct access to the commanding officer and have the authority to suspend, restrict, or terminate the operation of a laser or laser system. The LSSO must be trained to perform his/her assigned duties. As indicated in the Department of Energy's Special Operations Report: Laser Safety, the role, responsibilities and training requirements of a Laser System Safety Officer (LSSO) are critical factors for the success of a Laser Safety Control Program.

**Laser Safety Training Program for Laser Operators/Maintainers**

Safety training is a fundamental requirement of acquisition program support. OPNAV Instruction 5100.27A/Marine Corps Order 5104.1B requires that all Navy personnel in areas using Class 3b or Class 4 lasers and all personnel using Class 3a force-on-force lasers receive annual training about the potential hazards associated with accidental exposure to laser radiation. In particular, the extraordinary danger of eye damage due to focusing on lasers and absorption by the eyes is emphasized. The Instruction requires that, "Initial safety training and refresher training shall be appropriate to the operation." Inadequate training and a lack of understanding of the hazards and controls were factors in most laser accidents as reported in the Department of Energy's Special Operations Report: *Laser Safety*.

**Laser Safety Evaluations, Inspections and Surveys**

Per OPNAV Instruction 5100.27A/Marine Corps Order 5104.1B, laser facilities and ranges (other than medical facilities) shall receive local laser safety compliance inspections annually by an LSSO. This policy is to avoid the lack of oversight of laser operations, which was a contributing factor to laser exposures identified in the Department of Energy's Special Operations Report: *Laser Safety*.

**Laser Safety Equipment**

The Laser Safety Training Program ensures Navy personnel understand the importance of wearing proper PPE during laser operations. Lack of understanding of laser hazards will lead to a "failure to wear Personal Protective Equipment (PPE)," which is one of the common causes for laser accidents as identified in the Department of Energy's Special Operations Report: *Laser Safety*.

- **Laser Safety Eyewear:** Laser eye protection, which includes aviation visors with threat protection, is currently being distributed to the Fleet. It protects the user not only from the laser wavelengths used by U.S. forces and their allies but also from laser wavelengths used by potentially hostile nations.
- **Skin Protection:** Appropriate gloves and/or clothing are sufficient for lasers requiring skin protection. It should be noted that for extremely high-powered lasers such as Class 4 lasers, there is no protection available for direct exposure. Inaccessibility is the only appropriate protection.

Aviation Electrician's Mate 2nd Class maneuvers an AQS-24 mine locator, which is designed to use sonar and laser technology to photograph underwater mines. U.S. Navy Photo by Photographer's Mate 2nd Class Bradley J. Sapp

- **Laser Event Recorder (LER):** The LER was developed by the Vision Laboratory located at Naval Air Systems Command (NAVAIR) on board Naval Air Station, Patuxent River, MD. This LER instantly warns aviators about laser radiation potentially hazardous to their eyesight. The LER gives simple feedback to the aircrew at the time of a laser event and records detailed information onto a compact flash card for later analysis by intelligence officers, medical staff, and air crews. Sensors currently in use can't cover the complete range of laser threats, nor can they let aviators know whether or not a laser pointed in their direction is dangerous to eyesight.


Laser event recorder (LER) warns aviators of potential for eye injury from radiation

## Conclusion

By identifying and controlling laser radiation hazards early during the system design and development process, the DON has successfully protected personnel who operate or

otherwise come in contact with lasers from harmful effects of exposure. This acquisition and design process involves:

- Using designs that limit personnel laser exposures to levels that are within permissible exposure guidelines,
- Identifying, attenuating, or controlling through engineering design, administrative actions, or protective equipment, hazardous exposure levels and other dangers associated with non-ionizing radiation sources, and
- Controlling areas in which harmful exposure to unprotected personnel could occur.