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Laser Lessons News Letter

The Last Line of Defense - correct and properly fitted laser protective eyewear

This issue:

"...With the predominant usage of polycarbonate eyewear throughout the laser community, we need to be aware that there are limitations to our PPE and this is why one must seriously question the need to be near a laser beam where the irradiance requires >7OD. Remove yourself from the hazard and BE SAFE!"

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Introduction

In the previous issue we covered a lesson learned where an observant worker identified laser protective eyewear (LPE) that was incorrect for the job. This discovery may have saved the day for a less alert individual. We must never forget that there are many steps that must be taken prior to putting on LPE.

With any high powered laser operation, you must first make every attempt to lower the hazard/risk. This can be accomplished through lowering the laser output, containing stray reflections, using beam tubes, barriers, and even enclosing the laser system. These steps are the first line of defense; engineering to reduce the hazard as best as possible.

Once this is completed, you then may have to rely on LPE. LPE has limitations, as you will see in a "flash-back" lesson learned later in this issue. It is an administrative control and is the "Last Line of Defense."

Last Line of Defense

What are the most commonly spoken words after a laser eye exposure? HINT - It has to do with LPE... or should I say the lack of it. The most common thing an injured individual says is, "I only took them off for a moment to…" Does it really matter what the follow up words are? "I had to wipe my eyes, I was aligning the faintly visible beam and thought that I could see better without them, they were just uncomfortable, or I thought that I knew where the laser beam was." None of this matters when the aftermath is a permanently scarred retina and loss of vision.

Accidents happen when the individual loses respect for the danger at hand. Let's look at firearms. How many times do you hear about a gun owner accidently shooting themselves, someone else or even worse, a child getting the gun and accidently discharging it? Why does this happen? It's common sense that you don't play with a loaded gun right? So where is the disconnect? People become complacent and simply forget the dangers or feel that it won't happen to them.

Lasers are the same way. If you think of a beam line like the path of a bullet, you will see that containment, containment, containment is the answer.

Figure 1. Last line of defense against flooding on the Mississippi

It is bad enough if you hurt *yourself* from lack of beam control, but how would you feel if your coworker was blinded because you neglected to contain the beam?

There are times when you are working on a laser system and you need an open beam, this is where LPE comes in. You want that protection in case of an unanticipated event.

Before putting on any LPE you need to understand it. What does this mean? The eyewear should be thoroughly inspected. You want to be sure that it is physically solid. Look for cracks, pits, and scratches in the filter media.

There are two types of media for LPE, absorptive and reflective. The absorptive filter does just that, it absorbs the laser energy/ power in the polymer of the filter media. It generally covers a wide band of wavelengths.

The reflective media is a dielectric coating that reflects a fairly small band of wavelengths. With this type of media you want to ensure that there are not scratches or pinholes in the coating.

There are also two types of materials generally used for LPE, glass and polycarbonate. Both have positives and negatives.

Glass is able to withstand high intensity beams, but is generally heavy and limited in frame styles. It is also NOT impact resistant, limiting it's use in many environments.

Polycarbonate, on the other hand, is lightweight, can generally be formed into many different frame styles, and is impact safe. The negative is that a laser beam can burn through the filter media.

Figure 2. Glass vs. Polycarbonate Eyewear

Remember this when you are setting up a high power laser and you choose polycarbonate eyewear as your last line of defense. This eyewear was never intended to take a direct hit from a laser beam, i.e., looking directly into the laser.

So that you may gain some respect for what a laser beam can do to polycarbonate eyewear let's take a look at a lesson learned from 30 years ago.

Lesson Learned Flashback

Improper Laser Safety Glasses Key Factor In Serious Eye Injury

Reprinted from January 1986 DOE Serious Accidents Report

A laser scientist's right retina was severely burned by a 1.06 micrometer repetitively pulsed laser beam that melted a hole through the Laboratory-approved plastic laser safety goggles he was wearing. With full knowledge that the laser beam was on and passing through the cell that contained his experiment, the scientist looked directly into the cell. He said afterward that he had had confidence that the safety goggles would provide protection if he inadvertently looked into the beam.

While the scientist had more than nine years of prior laser experience, most of it had been with single-pulse ultraviolet (UV) gas lasers. He believes his experience with UV lasers lessened his awareness to the hazards that were present; a UV beam hitting plastic goggles would have caused the plastic to fluoresce, giving a warning. In addition, he had not thought about the amount of average power that was present due to the rapidly pulsing laser. The 1.06 micrometer pulsed laser was running at a specific power of approximately 20 watts per square centimeter; the repetition rate was 10 pulses per second; the energy was approximately 0.2 joules per pulse; and the length of each pulse was 30 nanoseconds.

The 1 micrometer laser beam presented a very severe eye hazard (~10E6 x Maximum Permissible Exposure) and a serious skin hazard (200 x Maximum Permissible Exposure). The injury was described as a 400 micrometer diameter crater burned into the retina of his right eye surrounded by a 3 millimeter diameter trauma region near the center of the field of vision.

The Experimental Setup

It was a typical tabletop experiment in which the scientist was studying phase-conjugate back-reflection by stimulated Brilluion scattering in a cell containing sulphur hexafluoride gas. The setup was relatively simple with the beam from the laser focused into the cell. There were windows on both ends to allow passage of the beam and a beam stop beyond the exit window. Diagnostics were set up in front of the cell. The laser output was properly shuttered, confined to the experimental table, and significantly below eye level.

The scientist had been thinking about his day's work when it occurred to him that if laser-initiated gas breakdown were taking place within the cell, the results of his experiment would be affected. He looked into the cell for a symptom of gas breakdown, a spark.

Filter-Glass Laser Safety Glasses Should Have Been Used

To our knowledge, the limitations of plastic-lens goggles in high-peak power and high-average power beams are not documented. After the accident, however, several pairs of plastic-lens goggles similar to those the scientist was wearing were tested in the laser beam at the location where the victim's had failed and at three other locations at higher specific powers. Safety glasses made of KG-3 filter glass, non-prescription, also were tested at the same locations. The plastic goggles were penetrated in 25- 35 seconds with a beam of 1.06 micrometer light operating at a specific power of 16 watts per square centimeter: the filter glass goggles survived the same beam operating at a specific power of 70 watts per square centimeter for 5 minutes with no damage, although they were hot to the touch. Clearly there is a big difference between these two types of eyewear in their capacities to handle high-average power laser beams. The injury would not have occurred had the employee been wearing filter-glass eye protection.

Synopsis

While a lot can be learned from this serious accident, one thing is certain, you should NEVER look into a laser beam, no matter what type of LPE you are wearing. This author is not aware of any other instance where a laser beam burned through LPE injuring the user. Every other reported accident has been due to the individual NOT wearing LPE at the time of the exposure.

The problem here was lack of implementing controls that would have prevented the individual from looking directly into the laser beam.

With the predominant usage of polycarbonate eyewear throughout the laser community, we need to be aware that there are limitations to our PPE and this is why one must seriously question the need to be near a laser beam where the irradiance requires >7OD. Remove yourself from the hazard and BE SAFE!

Figure 3. These plastic laser safety goggles failed when an experimenter looked directly into a repetitively pulsed laser beam. Although laser beams should not be viewed directly, and the goggle frames carried a warning against doing so, the consequences would have been less severe had he been wearing filter-glass goggles. Filter-glass safety goggles should be worn when working in laboratories where there are high-peak-power and high-average-power (repetitively pulsed or continuous wave) lasers. should not be worn by people who might be exposed to reflections or glints from such beams.

Artwork- John Jett

Lessons Learned

Unauthorized Modification of a Laser Safety Barrier

A user scientist (non-employee) at a DOE facility was performing Class 3R alignment laser work in an experimental area that can be secured with restricted access for Class 4 laser operations. The Class 4 laser is in a remote Laser Room. Two redundant Transport Shutters enable delivery of that laser to an interlocked enclosure on a large optics bench in the area. An additional pair of Exit Shutters permit laser transport from the enclosure to an experimental end station. The table enclosure panels must all be closed for Class 1 operation, but may be opened during Laser Off or Class 4 work. Laser operation modes in the area are summarized in Table 1.

Table 1: Access control and safety shutter permissives for each Operation Mode

Operation Mode	Access Control	Dual Transport Shutters	Dual Exit Shutters
Laser Enclosed - Class 1	None	Enabled and Open	Closed and Disabled
Laser ON – Class 4	Restricted by RFID to qualified laser personnel	Enabled	Enabled
Laser Off	None	Closed and Disabled	Closed and Disabled
Laser Off – Alignment	None	Closed and Disabled	Enabled

The user's alignment laser work was with the area in Laser Off Mode. The user wanted to transport the laser beam from the end station back through an optics path inside the table enclosure that would later be used for the high power beam, but was prevented from doing this by the dual Exit Shutters. These shutters are located inside a shutter enclosure, shown in Figure 4, that is inside the large table enclosure.

The Exit Shutters and the associated shutter enclosure are secured and affixed with labels stating, "Laser Safety Device – Do Not Remove or Modify without SLSO Approval.". SLSO is an acronym for the System Laser Safety Officer. To perform the desired work, the user should have consulted with the SLSO, who would have arranged for this to be done with the area in the Laser Off – Alignment mode. However, the user did not do this! Because the Hutch was in Laser Off mode, the user did not consider it would be unsafe to remove the shutter enclosure panel and prop open the 2 Exit Shutters. The user acknowledged reading the safety labels but did not perceive these actions as unsafe because of the Laser Off operation mode. When the user lifted the shutter blade, the engineered laser safety system generated a "shutter inconsistent state" interlock fault and sounded an audible alarm. This resulted in notification to an area manager and the SLSO, who subsequently found that a laser safety barrier had been modified without proper authorization.

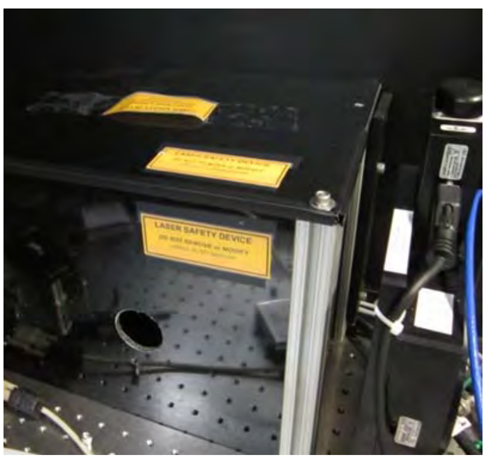

Figure 4: Shutter enclosure for the dual Exit Shutters

Lab management for the DOE facility investigated the incident and determined the unauthorized modification of the laser safety shutter/enclosure to be a significant event, and submitted a notification to DOE's ORPS reporting system. Corrective actions taken included: verification that the Exit Shutters and associated shutter enclosure were properly installed, configured, and secured; a reprimand letter from lab management to the user stating that tampering with a safety system is unacceptable and that willful disregard for adherence to safety policy will not be tolerated; and review of experimental area orientation procedures for adequate training on safety system configuration control.

Training

A newly revised version of the Laser Safety Training web-based course (HS5200-W) has been released. This is the product of nearly 18 months of work that involved representatives from: Ames Lab, LANL, LLNL, NREL, PNNL, SLAC, DOE Headquarters, DOE NTC, and DOE HAMMER Federal Training Center.

This course is now THE Standard Laser Safety Training for the entire DOE Complex. Laser Workers who provide support to other DOE Labs, using the course, will be granted reciprocity for completion. This will reduce time spent training and get you to work faster when visiting another DOE Lab. **BE SAFE!**

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