LIGO Laboratory / LIGO Scientific Collaboration

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A Quick Test of Laser Safety Eyewear

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LIGO Science Collaboration

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1 Introduction

With the planned upgrades to the LIGO detector involving high laser powers, a natural question to ask is whether the laser safety eyewear currently in use is still sufficient. Therefore, a quick test of some old laser safety eyewear was performed with the 35-W Enhanced LIGO Laser and the 200-W Advanced LIGO Laser. The test involved exposing the laser safety eyewear material to the laser and making a note of the result.

2 The Lens Material

A small sample of the laser safety eyewear available was tested. The first round of tests were conducted with two absorptive Schott glass filters used in laser safety eyewear. A second round of tests were conducted to test the plastic, or polycarbonate, style of laser safety eyewear. The polycarbonate material was of particular interest due to problems discovered with the laser safety eyewear at the 40m Lab (see ***LIGO-M080004-00-M***).

2.1 Schott Glass KG3

KG3 is designed by Schott for use as an absorptive infrared filter. The transmission for a 2 mm thick sample of KG3 is shown in Figure 1.

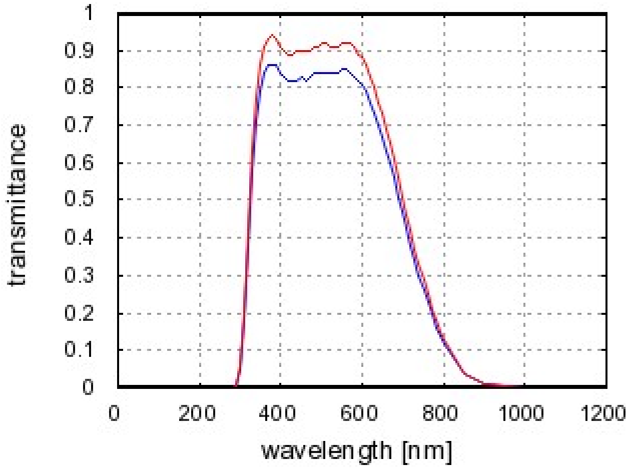


Figure 1. The transmission for a 2 mm thick sample of KG3. The upper, or red, curve is the internal transmittance.

2.2 Schott Glass KG5

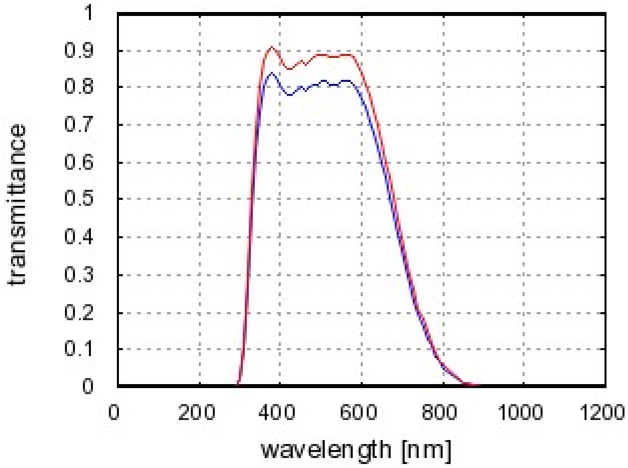


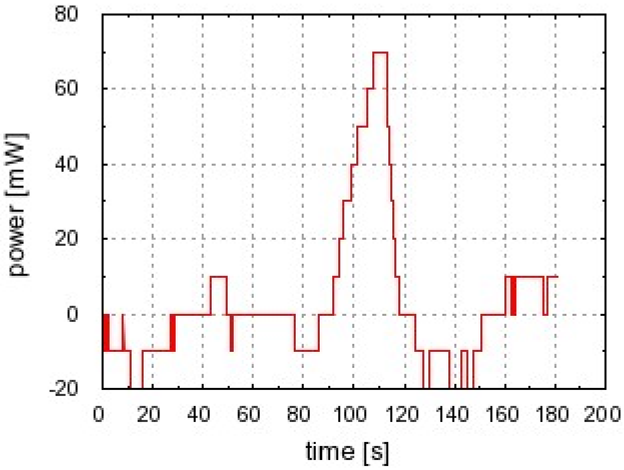
Figure 2. The transmission for a 2 mm thick sample of KG5. The upper, or red, curve is the internal transmittance.

3 Exposure Tests

Due to some laser problems, the Advanced LIGO Laser only delivered about 140 W. The Enhanced LIGO Laser delivered 35 W. The lens was setup in the beam path and a calorimeter was installed behind the lens to see if any power was transmitted by the lens upon impact. The lens was then exposed to the laser beam for a short duration and the result was recorded. A problem with this style of test is that in order to measure the transmission through the lens, a sensitive calorimeter must be used. However if the lens were to transmit close to 100% of the incident power, then the calorimeter would be damaged.

3.1 KG3

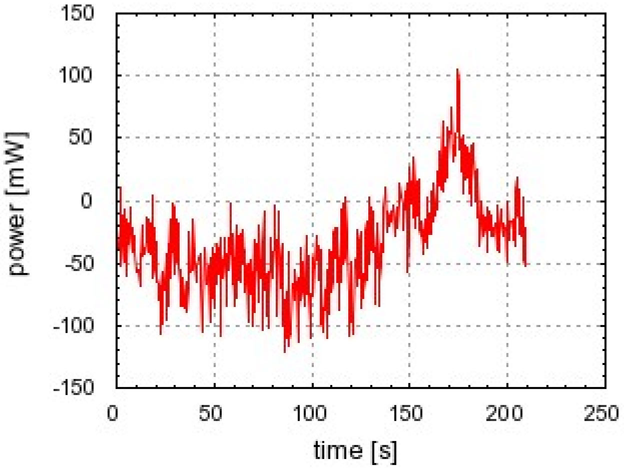
The KG3 lens was placed in the output of the Enhanced LIGO Laser where the beam diameter was approximately 3 mm. An Ophir LaserStar FL300A-SH calorimeter was used to record the power transmitted through the lens.



The maximum transmitted power measured was 70 mW. The video recording can be viewed here for .mov players or here for .avi players. The streak present in the video is due to saturation of the CCD element and is not the laser beam.

3.2 KG5

The KG5 lens was placed in the output of the Advanced LIGO Laser where the beam diameter was approximately 5 mm. A Coherent LM-45 HTD calorimeter was used to record the power transmitted through the lens.

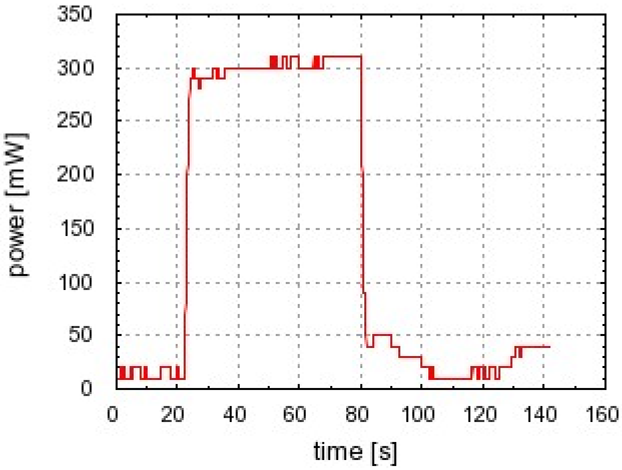


The maximum transmitted power measured was approximately 90 mW. The video recording can be viewed here for .mov players or here for .avi players.

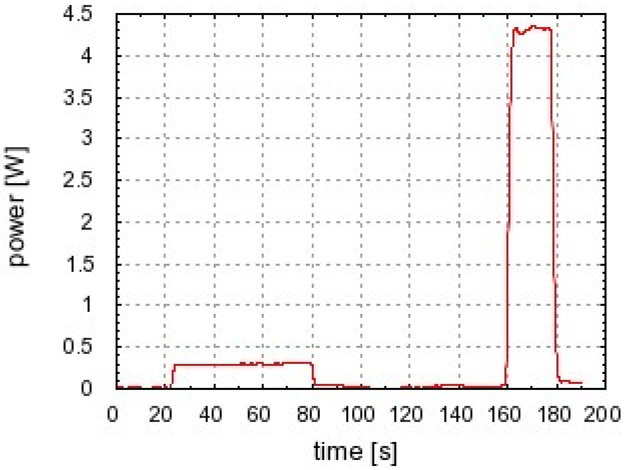
3.3 Uvex LC542 C739

These polycarbonate laser safety eyewear were in use at the 40m Lab. The frames list an optical density of 5+ at 1064 nm. These rely on reflective coatings to reflect any incident laser light. The problem experienced at the 40m Lab is that over time, the reflective coatings became damaged either through a problem with the coating or mis-handling. This style of laser safety eyewear is shown in Figure 3. The beam diameter used in this experiment was approximately 5 mm.

Figure 3. The Uvex LC542 C739 laser safety eyewear that was used at the 40m Lab. On the right is a close-up view of the damaged coating region.



The transmission measured with the laser beam aimed at the centre of the lens, away from the damaged coating area. The maximum transmitted power measured was approximately 300 mW. The video recording can be viewed here for .mov players or here for .avi players.

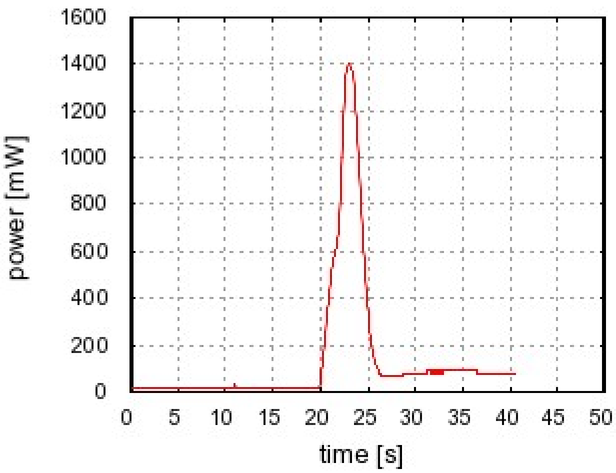


The transmission of the damaged coating region. Note the change in scale compared with previous measurements. The maximum transmitted power measured was approximately 4.3 W.

In both measurements, transmitted power through the eyewear was observed as soon as the beam block was removed.

3.4 Flex Seal Z94.3, Uvex Z87

The Flex Seal Z94.3 and Uvex Z87 appear to be made from similar materials and are absorptive polycarbonate filters. Uvex clearly states on the eyewear that it is for viewing of diffuse laser light only.



The transmission through the Flex Seal Z94.3. The maximum power transmitted was 1.4 W. The time scale is mis-leading as the power transmitted coincided with the laser light being incident on the laser safety eyewear. The measurement was rapidly shutdown to preserve the cleanliness of the laboratory.

4 Results

For both Schott glass filters, there was no transmitted power for a period of at least a few seconds. Unfortunately a synchronised time resolved measurement was not possible but observing but observing the calorimeter during the exposure period revealed no significant departures from zero during the early stages. After removing the beam, the damage to the glass is apparent, with a small crater being present with small cracks where the beam was incident on the glass. As each lens cooled down, the whole lens cracked. It is important to note that the lens did not shatter when exposed to the beam.

In the case of KG5, a hole was made through the glass. There is evidence that the beam melted the glass material and some kind of sticky, oily substance oozed out.

Surprisingly for the Uvex LC542 C739 laser safety eyewear no evidence of damage by the laser was visible. Even in an area where the thin-film coating appeared to be visually okay, the power transmitted by the eyewear was well above any applicable maximum permissible exposure level. This would suggest a defect in the coating and some difficulty in verifying if the coating was okay or not.

Although tested beyond its intended use, the Flex Seal Z94.3 performed the worst with damage being done the instant the laser was incident on the eyewear. This type of laser safety eyewear should not be used for any work around the laser table. Given the reasonable number of this style of eyewear already present on the Project, they could be used for the tour groups that visit.

5 Conclusions

My personal conclusion from these tests is that we should follow the CE standard and require a period of time where the laser safety eyewear can withstand a direct hit. Absorptive, glass-based filters are preferred over the thin-film based polycarbonate laser safety eyewear because of concerns about the longevity of the reflective coatings. Even the extra time afforded by CE certified laser safety eyewear would give a laser operator time to get out of harm’s way. Frankly after seeing the video, if a person couldn’t tell that they were being hit by the laser then there are more immediate problems at hand.