LASER-PROFESSIONALS Inc.

Where the laser user comes first

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TO: Laser Safety Personnel

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SUBJECT: SELECTING EYEWEAR FOR SHORT PULSE LASERS

INTRODUCTION

In recent years lasers producing short and ultrashort pulses have become common research tools. The high peak irradiance values produced by such lasers can result in photobleaching of laser safety eyewear. This memo provides practical guidance on selecting laser safety eyewear for short and ultrashort pulse lasers. It will be updated as new data becomes available.

LASERS OF CONCERN

Common lasers for which eyewear photobleaching is a concern include mode-locked Ti:sapphire and Nd:YAG lasers and Q-switched Nd:YAG lasers with short pulses. Ti:sapphire laser systems typically produce pulses in the femtosecond range with a central wavelength of about 800 nm. These are often frequency doubled to the blue. Q-switched Nd:YAG lasers operating at 1064 nm typically produce pulses with durations of a few nanoseconds. Mode-locked Nd:YAG lasers typically produce pulses in the picosecond range. Harmonic generators are commonly used with these lasers to produce outputs at 532 nm, 355 nm, and 266 nm. The use of OPOs and other wavelength conversion devices can produce short pulses at any wavelength in the ultraviolet, visible, near IR, or far IR.

EYEWEAR FOR FUNDAMENTAL WAVELENGTHS (IR)

Glass eyewear for the Nd:YAG fundamental wavelength of 1064 nm is usually made of KG3 of KG5 glass. These clear glasses provide high OD with high visible light transmission. Glass eyewear for the Ti:saph fundamental wavelength of 800 nm is usually made of BG39, BG42, or BG18. These blue glasses also provide protection at 1064 nm.

Published studies confirm that blue glass does not photobleach for picosecond or femtosecond pulses. We have been told by several sources that KG3 and KG5 do not photobleach for picosecond pulses, but we have also heard that it does photobleach for femtosecond pulses. We hope to obtain data to confirm this soon.

Green colored polycarbonate eyewear with an OD of 7 @ 1064 nm has been manufactured by many companies for decades. Many samples tested for short pulse transmission before the year

2000 exhibited photobleaching. Recent tests of modern eyewear from Glendale indicate no photobleaching for picosecond pulses. Green YAG eyewear of unknown vintage must be considered unsafe for short pulse use unless it is tested under worst-case use conditions.

Glendale polycarbonate eyewear model # 30-30300 is for use with Ti:saph lasers and is rated for femtosecond pulses.

NoIR polycarbonate eyewear AXX, YG3, and YG2 are rated for femtosecond pulses for Ti:saph, Nd:YAG, and both, respectively.

EYEWEAR FOR SECOND HARMONIC

Glass eyewear for the frequency-doubled Nd:YAG wavelength of 532 nm is usually made of OG570. This orange glass also protects from all shorter wavelengths. ***Most orange glass exhibits severe photobleaching and should never be used for short pulse protection.***

Orange polycarbonate eyewear with an OD of 7 @ 532 nm has been manufactured by many companies for decades. Tests performed on modern products indicate no photobleaching for picosecond pulses.

MULTIWAVELENGTH PROTECTION

Laminated glass eyewear for Nd:YAG and harmonics is usually made of OG570 and BG42. Other blue glasses or KG5 may also be used. This eyewear does not photobleach in the infrared. It should not be used for short pulse blue or green protection because of severe photobleaching of the orange glass.

Brown polycarbonate eyewear for Nd:YAG and harmonics contains the green dye for the fundamental wavelength and the orange dye for the frequency-doubled and shorter wavelengths. Older models may photobleach in the infrared.

Glendale polycarbonate #31-3983 has been tested for picosecond pulses at both infrared and green wavelengths and did not photobleach.

Glendale #31-30123 is rated for femtosecond pulses, VLT of 25%, and has the following ODs:

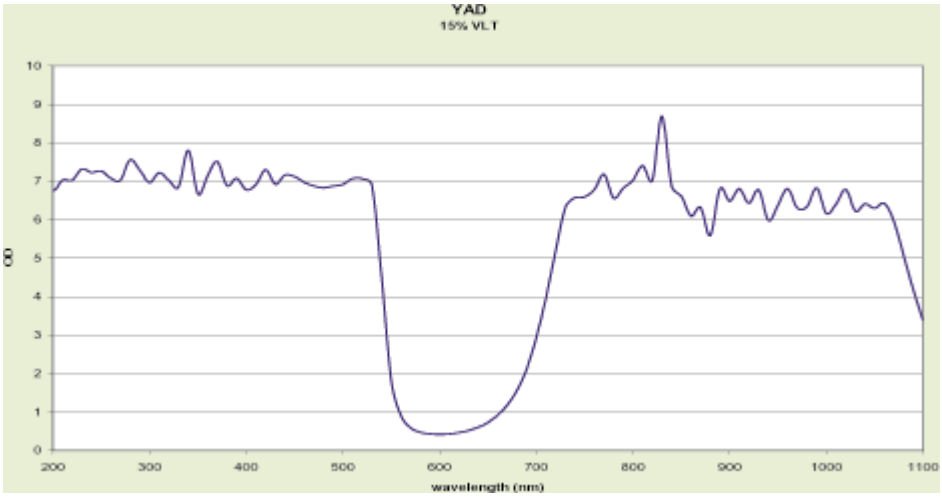
190 – 520 nm	OD >9	710 – 750 nm	OD >3
520 – 532 nm	OD >7	750 – 850 nm	OD >5
		850 – 1080 nm	OD >7
		5000 – 11000 nm	OD >7

OD vs. Wavelength graph for Glendale #31-30123 not available.

http://www.glendale-laser.com/products/product_eyewear.asp?id=124

NoIR model YAD is rated for femtosecond pulses, VLT of 15%, and has the following ODs:

190 – 534 nm	OD >5
720 – 1064 nm	OD >5
740 – 1064 nm	OD >6



http://www.noirlaser.com/filters/yad.html

INFRARED PROTECTION

In some Nd:YAG laser systems mixing crystals and OPOs are used to produce wavelengths throughout the infrared. All polycarbonate eyewear mentioned above has transmission bands between 1200 and 5000 nm. Blue glass transmits between 1200 and 2800 nm. The best choice for eye protection for wavelengths greater than 1000 nm is usually KG5 glass. A transmission curve is available in the Schott Optical Filters catalog.

PROTECTION FOR LONG VISIBLE WAVELENGTHS

No short pulse data is currently available for eyewear in the wavelength range of 532 – 700 nm. In the range of 700 – 750 nm an OD of 3 is available from some polycarbonate filters and from BG39 and BG42.

Ti:saph mode-locked pulses with durations of 10 fs or less contain significant energy in wavelength range of 600 - 750 nm. Other ultrashort pulse systems are capable of emission across the entire visible. Eyewear for such systems must be evaluated by the LSO on an individual basis.

SUMMARY OF RECOMMENDATIONS

For nanosecond (Q-switched) or picosecond (mode-locked) Nd:YAG fundamental only use KG3, KG5, BG39, BG42, Glendale green polycarbonate #31-3982 or #31-3985 (or equivalent), or polycarbonate eyewear rated for femtosecond pulses at 1064 nm.

For mode-locked Nd:YAG and harmonics use Glendale polycarbonate #31-3983 (or equivalent) or polycarbonate eyewear rated for femtosecond pulses at 1064 nm and ≤532 nm. **DO NOT USE ORANGE GLASS FOR SHORT PULSE PROTECTION.**

For mode-locked Ti:saph fundamental only use BG39, BG42, or polycarbonate eyewear rated for picosecond pulses for 760 – 840 nm. Note that broader bandwidth protection is required for shorter pulses.

For mode-locked Ti:saph and harmonics use polycarbonate eyewear rated for picosecond pulses for 760 – 840 nm and 380 – 420 nm. Note that broader bandwidth protection is required for shorter pulses. An alternative is the use of BG39 or BG42 with an orange polycarbonate filter.