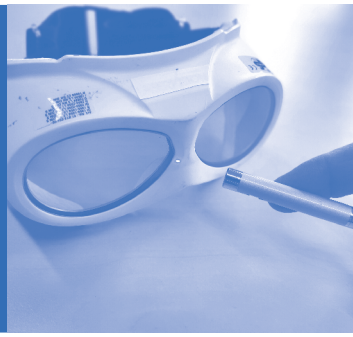
Aging resistance of laser safety filters

Investigation of the protection effectiveness of „used“ laser safety filters and glasses.



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Laser radiation is now part of everyday life in many areas of work. Even with following the hierarchy of control measures for safety (elimination, substitution, engineering, administrative) there are situations at an organization in which the use of laser protective eyewear (LPE) must be utilized. Laser safety goggles are specialized products that are often in use for many years and are rarely replaced without a specific reason. For the user, however, this raises the question of whether glasses still provide sufficient protection after a long period of time or intensive use.

In a research project with the Bavarian Laser Center (BLZ), the Federal Institute for Occupational Safety and Health (BAuA) investigated this question. In this, the influence of „aging“ on certain optical properties of laser protection filters from the standard materials polymethyl methacrylate (PMMA) and polycarbonate (PC) was determined. The investigations were carried out on both artificially aged and laser protection filters which were in use for years and thus aged naturally.

How the protective properties for laser safety goggles are to be determined is specified in the DIN EN 207 standard. The standardized tests described therein ensure the protection of the eyes against laser radiation. Laser safety goggles are considered suitable if the filter can withstand a direct laser bombardment in continuous wave operation (CW operation, laser mode D) at least 5 s and with pulsed lasers (laser operating modes I, R and M) at least 5 s and at least 50 pulses. In addition, the standard describes further requirements for selected optical parameters:

- The maximum spectral transmission degree of the filter must not be exceeded at the designated wavelength and protection level.
- A degree of light transmission, based on the standard light type D65, of at least 20 % must be guaranteed. A fall below is permissible if the manufacturer indicates a corresponding increase in illuminance.
- Except for the edge areas, the filters must not have any visually impaired errors (turbidity, scratches, etc.). The light scattering, determined by means of the reduced luminance coefficient, must not be greater than 0.5 $cd \cdot m^{-2} \cdot lx^{-1}$.

To carry out the artificial aging, one of the two unused glasses was mounted in the “Xenon Suntest” irradiation chamber at the test facility (LEMA s.r.l., Italy). Within the chamber there is a turntable with 15 radially symmetrically arranged and adjustable mounted test brackets. The xenon high-pressure lamp with an output of 450 W (OSRAM XBO 450W/4) is centrally mounted on the turntable. To allow a systematic study of UV aging, some of the filters were irradiated for 50 hours and others for 200 hours, which corresponds to permanent storage for several years under direct sunlight. This was intended to simulate different aging states.

In addition to pure UV aging, some PMMA filters were exposed to the xenon arc radiation and moisture to artificially reproduce weathering effects such as temperature and humidity changes and then test the service life of the laser protection filters. The current reference standards for this are Parts 1 and 2 of DIN EN ISO 4892. For the artificial weathering, the irradiation and weathering tester„Xenotest Beta+“ by Atlas Materials Testing Technology (USA) was used. The filters were irradiated at a sample chamber temperature of 38° C, a black radiator temperature of 65° C and a relative humidity of 60% with three air-cooled 2200 W xenon lamps and rained in parallel cycles every 102 min for 18 min each. The irradiance was 60 W·m-2 and the total irradiation duration 100 h (equivalent to 50 irradiations).

The laser protective filters artificially aged by means of UV radiation do not depict reality faithfully, but rather serve to determine the aging resistance under defined and thus comparable conditions.

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Therefore, the consideration of the protective properties of laser safety goggles, which have already been in real use for years, is particularly interesting. For this purpose, used laser safety goggles were recovered from operational practice in a complex action. If identical new products were still available on the market for these glasses, they were procured, the laser resistances of the old glasses and their brand-new counterparts were tested and then compared with each other.

To detect aging effects, the 5 s test duration specified in the DIN EN 207 standard was deviated from and irradiated until it was shot through. For this purpose, the time until the shot through of each filter was measured, by determining the time span from the start of irradiation to the detection by the test filter of transmitted laser radiation with a photo paper. This time difference represents the service life of the laser protection filter and serves as a comparison criterion between differently aged samples

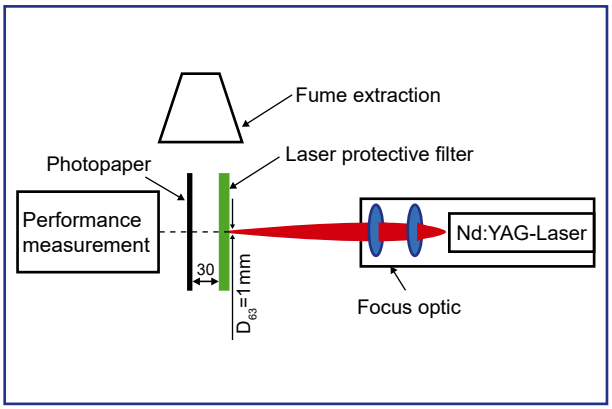

Fig. 1 Schematic arrangement of the measurements for determining the service life of laser protective filters at a wavelength of 1064 nm.

Using the example of a PMMA filter, there is only a small influence of artificial aging on the service life and thus on the protective effect. The PMMA filters are certified for D LB6 at 1064 nm, which corresponds to a laser power of 7.85 W for 5 s. The tests showed a filter service life of about 30 s with a set laser power of 30 W. Thus, the set laser power was about a factor of 4 higher than the protection level D LB6 requires. Even with the service life tests on artificially UV-aged PC filters as well as with the old filters, the results were clearly above the standard specifications.

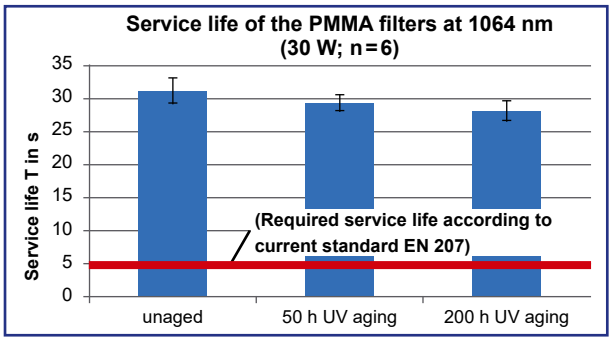

Fig. 2 Service life of the PMMA filters

The filter parameters optical density and light transmission showed no significant changes due to UV aging. Only in the scattered light measurement, the PMMA filters showed a slight exceedance of the standard specifications after 200 h UV irradiation. As a result, such glasses only allow limited vision and must therefore be replaced. One reason for the increase in scattered light values is probably the surface change of the filters (roughening) due to UV exposure. However, this has no negative effect on the safety of the filters during laser irradiation.

Even after 200 hours of UV irradiation, which would correspond to years of exposure of the filters in direct sunlight, there is only a slight decrease in laser resistance. Only in the case of artificially UV-aged PMMA filters have the values of the light transmission reached the limits specified in the test standard DIN EN 207 and have been partially exceeded in the case of scattered light.

When comparing old filters with identical new filters, no critical decrease in the protective function could be detected regarding laser resistance. Even for 20-year-old glasses, the values determined were well above the (DIN EN 207) standard specifications.

Result

The results of the investigation show that the age of laser safety goggles alone is not a limiting criterion with regard to the laser resistance of PMMA and PC filters at the investigated laser wavelengths of 1064 nm (Nd:YAG) and 10600 nm (CO2 laser). Rather, users should pay attention to the apparent overall condition as well as possible mechanical damage as just the mere age before using laser safety goggles.

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