YAMAMOTO

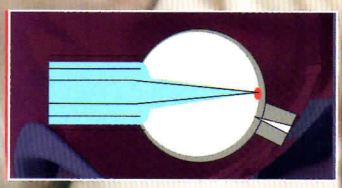
L-003E

LASER EYE PROTECTOR & FILTER

MEDICAL TREATMENT

OPTICAL FILTER

YAMAMOTO KOGAKU CO.,LTD.



LASER SAFETY

GOGGLES

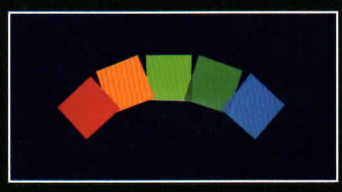
INNER FRAME & OUER GLASSES

Protecting for you

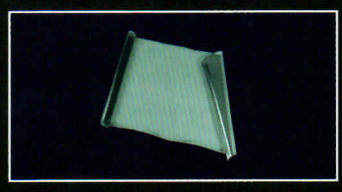
Yamamoto's motto is "Protecting for you" and we have been developing Petroid(*1) lens, which makes safe and comfort "vision" using core technology of light safety glasses and various protective products.
And based on the filtering technology that we established over the last 20 years, we have developed dust respirators and PAPR(powered air purified respirator) as a pioneer of the market. As for Laser protective glasses, we have developed broad range of products for various laser wavelengths with the developments in Laser technologies.
We make every effort to contribute to create safe, healthy, rich and pleasant life for working peoples.

OVER GLASSES

GLASSES

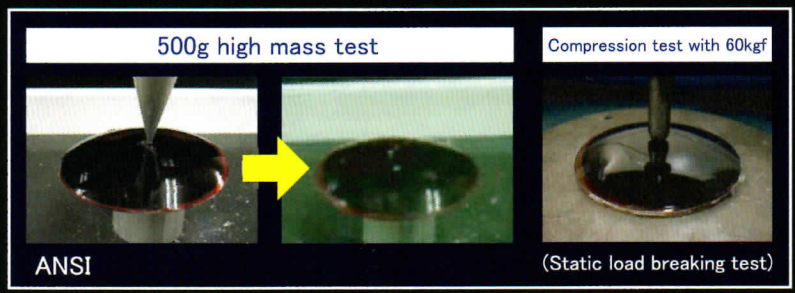


WINDOW



CURTAIN

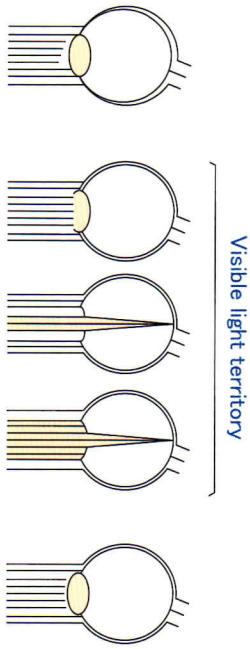
(*1)
"Petroid" lens is best suited for the use in sports and occupational safety, which Yamamoto can be proud of. It is made of polycarbonate which has tens times of toughness than mineral glass. It was developed with taking advantage of the material characteristic of polycarbonate. It has been the best quality optical product with superior clarity and distortion-free high definition, which is the basis of our safety glasses.



Hazards of Laser

Laser is artificially made and particular kind of light, and it has completely different from natural light. It has directional characteristics, and the monochromatic behavior focuses all of energy on one point. It may become high power enough to melt the metal in a moment.
According to such characteristics of the laser, although the laser related workers know well about it, the failure of prevention measures as risk management may increase the possibility of accidents.
Especially against eyes, it is told that the focusing behavior of the crystalline makes the damage of retina bigger than expected. It is recognized that eye damages will be problematic on a permanent basis.

Table 1 Influence on the eyes according to wavelength

Absorption overview on an eyeball	Wavelength(nm) by CIE standard	Effect and damage to the eyes
	UV: UV-C 200–280, UV-B 280–315, UV-A 315–400 Visible 400–780 IR: IR-A 780–1,400, IR-B 1,400–3,000, IR-C 3,000–10^6	Inflammation causes an acute pain to cornea and conjunctiva due to photochemical action and thermal effect. Clouds of crystalline lens due to thermal effect(cataract) Retinal damage due to photo-chemical action by visible light. Retinal damage due to photo-chemical action, thermal effect and impact wave. Cornea burns and cataract due to thermal effect

CIE is an abbreviation of Commission Internationale de Enluminure.
Diagram: Influences to the eyes in case of exposure to excess laser irradiation

It is specified (JIS C 6802) that eyes must be protected from Laser between wavelength of 180nm and 1mm. As described on the table 1, the damaging part of the eyes depends on the wavelength.

In UV area (below 400nm), most of Laser is absorbed at the surface of cornea and the rest is absorbed by crystalline. The irradiation of high power UV Laser makes inflammation (burns) on cornea due to photochemical action in the short term and it may form the cataract in case of the long exposure.

As for visible light area (400–700nm), when people senses the glare, blinking protective response is brought, however, it is too late to protect eyes in terms of time.
Laser comes into the eyes before the 0.25 sec. of protective response after catching a scent of danger. It is given an indication that Laser below 1mW power is safe even if Laser comes into the eyes in such 0.25 sec. However, due to thermal effect and focusing behavior of the eye lens, the higher power than 1mW may give damages on the part of retina on a permanent basis.

As for near-infrared area (700–1400nm), Laser reaches to the retina in the same way as visible light area. Since it is the invisible area, people can not recognize the damages, that is the reason why it is called as the most dangerous wavelength ranges.

The problems of after effects (low vision)

Most of the recorded accident examples by the Laser were occurred in the area of near-infrared. It is not the indication that the protection measures shall be only against near-infrared, which should be considered as the popularity of certain Laser devices.
The most important point on the reported accidents is that the damages on retina may lead to the low vision. In this case, it is big problem that no visual recovery is expected basically.

Classification of Laser(IEC60825-1)

Each class is defined with AEL(Accessible Emission Limit):

Table 3 classification of Laser

Class 1	Low power level Laser: A class 1 laser is safe under all conditions of normal use. Built-in Laser: No access in normal use, however, it may be dangerous if the interlock system is not working.
Class 1M	Low power level Laser, parallel and large diameter beam: A Class 1M laser is safe for all conditions of use except when passed through magnifying optics such as microscopes and telescopes.
Class 2	Low power level Visible Laser; A Class 2 laser is safe because the blink reflex will limit the exposure. It may cause damage to the eyes in case of long time exposure against blue light, which is especially dangerous.
Class 2M	Low power level Visible Laser, parallel and large diameter beam; A Class 2M laser is safe because of the blink reflex if not viewed through optical instruments.
Class 3R	A Class 3R laser is considered safe for 100 seconds against invisible Laser and 0.25 seconds against visible Laser even if the MPE be exceeded, but with a low risk of injury, although beam viewing is restricted. The max power is 5 x AEL's of Class 1(invisible Laser) or 5 x AEL's Class 2(visible Laser).
Class 3B	A Class 3B laser is hazardous if the eye is exposed directly, but diffuse reflections such as from paper or other matte surfaces are not harmful.
Class 4	Class 4 lasers include all lasers with beam power greater than class 3B. A direct or diffuse beam viewing is dangerous.

It is important to check the class of your Laser so that you can take measures of prevention from radiation hazards.

Use of Laser protective eyewear

Notices of Health, Labour and Welfare Ministry "The protection measures for the hazard of Laser beam" requests users of 3R laser device to wear an appropriate protective eyewear according to the wavelength of Laser as safety precaution for working management

CE marking

European Norm(EN207, EN208)
Laser protective eyewear must protect eyes for 10 seconds against CW Laser and for 100 pulses against pulse Laser. Both filter and frame must be fulfilled the requirement of European Norm.

Example of CE marking performance indication on lens:
"DIR 925-1065 L5"
The protection level is inscribed on the lens along with CE marking.

- DIR means the emission type of laser which is used when testing(D stands for Continuous Wave laser, I = Pulse laser and R= Q switched laser.).
- The numbers of 925-1065 stands for the testing range from 925nm to 1065nm.
- The rightmost L5 stands for protection level of the tested protective eyewear(Classification of 10 grades of protection levels). EN207 includes EN208 which standardizes the protective eyewear for the alignment works with visible lasers, which are classified in 5 grades using R instead of L although the same laser emission test is performed.

Following tables are the reference of power level (testing level) against wavelength ranges:

Table 4 EN207

Scale number	Maximum spectral transmittance for laser wavelength $\tau(\lambda)$	Power(E) and energy density(H) for testing the protective effect and stability to laser radiation in the wavelength range								
		180nm to 315nm			>315nm to 1400nm			>1400nm to 1000μm		
		For test condition								
		D	I,R	M	D	I,R	M	D	I,R	M
		>3·10⁴	10⁻⁹to	<10⁻⁹	>5·10⁻⁴	10⁻⁹to	<10⁻⁹	>0.1	10⁻⁹to	<10⁻⁹
			3·10⁴			5·10⁻⁴			0.1	
		E_D	$H_{I,R}$	E_M	E_D	$H_{I,R}$	H_M	E_D	$H_{I,R}$	E_M
		W/m²	J/m²	W/m²	W/m²	J/m²	J/m²	W/m²	J/m²	W/m²
LB1	10^{-1}	0.01	$3\cdot10^{2}$	$3\cdot10^{11}$	10^{2}	0,05	$1{,}5\cdot10^{-3}$	10^{4}	10^{3}	10^{12}
LB2	10^{-2}	0.1	$3\cdot10^{3}$	$3\cdot10^{12}$	10^{3}	0,5	$1{,}5\cdot10^{-2}$	10^{5}	10^{4}	10^{13}
LB3	10^{-3}	1	$3\cdot10^{4}$	$3\cdot10^{13}$	10^{4}	5	0,15	10^{6}	10^{5}	10^{14}
LB4	10^{-4}	10	$3\cdot10^{5}$	$3\cdot10^{14}$	10^{5}	50	1,5	10^{7}	10^{6}	10^{15}
LB5	10^{-5}	100	$3\cdot10^{6}$	$3\cdot10^{15}$	10^{6}	$5\cdot10^{2}$	15	10^{8}	10^{7}	10^{16}
LB6	10^{-6}	10^{3}	$3\cdot10^{7}$	$3\cdot10^{16}$	10^{7}	$5\cdot10^{3}$	$1{,}5\cdot10^{2}$	10^{9}	10^{8}	10^{17}
LB7	10^{-7}	10^{4}	$3\cdot10^{8}$	$3\cdot10^{17}$	10^{8}	$5\cdot10^{4}$	$1{,}5\cdot10^{3}$	10^{10}	10^{9}	10^{18}
LB8	10^{-8}	10^{5}	$3\cdot10^{9}$	$3\cdot10^{18}$	10^{9}	$5\cdot10^{5}$	$1{,}5\cdot10^{4}$	10^{11}	10^{10}	10^{19}
LB9	10^{-9}	10^{6}	$3\cdot10^{10}$	$3\cdot10^{19}$	10^{10}	$5\cdot10^{6}$	$1{,}5\cdot10^{5}$	10^{12}	10^{11}	10^{20}
LB10	10^{-10}	10^{7}	$3\cdot10^{11}$	$3\cdot10^{20}$	10^{11}	$5\cdot10^{7}$	$1{,}5\cdot10^{6}$	10^{13}	10^{12}	10^{21}

D=continuous wave laser, I=pulsed laser, R=Q switch pulsed laser(short pulses), M=mode-coupled pulsed laser(ultra short pulses). Reference:E207

testing conditions for laser type	typical laser type	pulse length(s)	number of pulses
D	continuous wave laser	5	1
I	pulsed laser	$>10^{-6}$ to 0.25	100
R	Q switch pulsed laser	$>10^{-9}$ to 10^{-6}	100
M	mode-coupled pulsed laser	$>10^{-9}$	100

(EN208)

Scale Number	Max. transmittance	Max. laser power in W (1)	Max. pulse energy in J (2)
RB1	10^{-1}	0.01	2×10^{-6}
RB2	10^{-2}	0.1	2×10^{-5}
RB3	10^{-3}	1	2×10^{-4}
RB4	10^{-4}	10	2×10^{-3}
RB5	10^{-5}	100	2×10^{-2}

(1) CW lasers and pulsed lasers with a pulsed length of $>2\times10^{-4}$S
(2) pulsed lasers with a pulse length $>10\text{-}9$ to 2×10^{-4}S

Selection of laser protective eyewear

(1) Wavelength of the laser (nm)
(2) Power of the laser
CW laser: power (W)
Pulse laser: Power / pulse (J) and Frequency (Hz)
(3) MPE(Maximum Permitted Exposure)
(4) Exposure time (min)
(5) Maximum radiation exposure
(6) Required OD(Optical Density)

MPE(Maximum Permitted Exposure)
MPE is defined as 1/10 of amount of exposure with injury probability of the 50%
in case of direct laser hitting.
It stands for one of the safety level against human body, which is calculated with wavelength and exposure time.
MPE by direct hitting laser and diffused laser are calculated separately.
Please be aware that MPE is used as the barometer of managing exposure amount but as thresholds medically against human body.

Calculation of OD
●Relations among laser, protective equipment and eyes
When selecting protective eyewear, basically it is needed that lasers of Class 3B and 4 should be attenuated to below MPE by the protection filters.

How to select laser protective eyewear.

1 Check the type of laser, wavelength and power of your laser.

Even if the same name of the laser, the wavelength might differ.
Even if the different laser type, the wavelength might be same. Please check the characteristic graphs on each page.

2 Choose the filter type

D Laser absorption type
Optical density(OD) is high and you can not see the laser.

C Laser absorption type and Application for Multi band laser
One goggle is available for multiple laser wavelengths.

M Type attenuation to 1/100 for alignment work
Alignment for the laser power less than 100mW.(OD1 to 2)
Please use this type for checking the laser path and optical axis alignment.

A Type attenuation to 1/10,000 for alignment work
Alignment for the laser power less than 10W.(OD4)
Please use this type for checking the laser path and optical axis alignment.

H High power laser absorption type
High OD and good damage threshold.

G Tempered glass laser absorption type
Tempered glass provides high visibility.

3 Choose the frame type

YL-130 GOGGLE
Very good fit with face and can be worn over the prescription glasses.

YL-717 OVERGLASS1
Can be worn over the bigger prescription glasses.

YL-290 GLASS
Light & compact glasses with easy wearing semi-straight temples.

YL-250 OVERGLASS
Tempered glasses give high visible transmittance

YL-760 OVERGLASS
Inner frame with prescription lenses can be attached inside of this glass. In case of no inner frame, it is used as over glass type.

YL-331 & YL-335 OVERGLASS2
Can be worn over the normal sized prescription glasses.

YL-120 GOGGLE
Laminated glasses provide very high threshold against high power laser.
* Threshold stands for the limit that the laser radiation starts to give damages.

The other products:

YL-500・YL-550
Laser shield window

YL-600・YLC-1・YLC-2
Laser shield curtain

YL-2200
Laser barrier curtain

4 Check the item numbers

●Example of goggles and glasses:

YL-120H YAG

- YL-120H: the symbol of laser protective eyewear
  - GOGGLE TYPE (130・120)
  - GLASS TYPE (290)
  - OVERGLASS TYPE (760・717・331・250)
- YAG: the name of filter
  - D Laser absorption type
  - C Laser absorption type ans application for Multi band laser
  - M Type attenuation to 1/100 for alignment work
  - A Type attenuation to 1/10,000 for alignment work
  - H High power laser absorption type
  - G Tempered glass laser absorption type

●Example of window and curtain:

YL-600C Nd-YAG 2

- YL-600C: the symbol of laser window and curtain
  - CURTAIN (600)
  - WINDOW (500)
- Nd-YAG 2: the name of filter
  - D Laser absorption type
  - C Laser absorption type and application for Multi band laser

What is Optical Density(OD)?

OD stands for the attenuation rate of the incoming laser beam through lens.
OD shall be calculated as following math formula:

$OD(\lambda) = \log10(PI(\lambda)/PT(\lambda)) = -\log10T(\lambda)$

PI stands for incoming angle, PT is the power which passed the lens, T stands for the transmittance of the specific wavelength.
The bigger the number of OD gets, the attenuation rate gets higher, which stands for better protection.
On the contrary, the bigger the number of OD gets, the transmittance rate gets lower.
Please check the following table:

Optical Density (OD)	Transmittance	Attenuation rate
0	100%	0
1	10%	1/10
2	1%	1/100
3	0.1%	1/1000
4	0.01%	1/10000
↓	↓	↓
10	0.00000001%	1/10000000000

Please contact us for further information.

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