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TECHNICAL REPORT
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Laser Filter Inserts for Goggles, Sun, Wind and Dust

by

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In order to provide eye protection for military personnel, two types of laser-protective filter elements were developed for use as inserts in the Goggles, Sun, Wind, and Dust. The elements were designed to be snapped into the goggle frame in back of the standard ballistic lens. A total of 600 Type A filter elements with optical density greater than 4.0 at 400-532 nm and photopic transmission of 44% were delivered to the U.S. Army Natick RD&E Center. These elements met contract requirements with the exception of photopic transmission and resistance to sodium hypochlorite solution.

A total of 275 Type B filter elements with optical densities exceeding 4.0 from 694-1064 nm were delivered to Marine Corps Systems Command. These elements measured substantially below the desired 25% minimum photopic transmission, exhibited excessive optical distortion and dye nonuniformity, lost abrasion protection after contact with sodium hypochlorite solution, and lost hard-coat adhesion after simulated exposure to sunlight.

14. SUBJECT TERMS

LASER FILTERS	LASER PRTECTIVE FILTERS	ABRASION RESISTANCE
GOGGLES	TEST AND EVALUATION	CHEMICAL RESISTANCE
EYE PROTECTION	ROBUST FILTERS	OPTICAL DENSITY

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CONTENTS

PREFACE

This study of laser filter inserts for Goggles, Sun, Wind and Dust was undertaken by Harry A. Smith and Monis J. Manning of Polaroid Corporation's Holographic Products Division, Cambridge MA during the period July 1991 to May 1993. The funding was under U.S. Army Natick Research, Development and Engineering Center Contract DAAK60-91-0062 and the Natick Project Officer was Edward M. Healy.

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LASER FILTER INSERTS FOR GOGGLES, SUN, WIND AND DUST

1. SUMMARY

Our goal under this contract was to provide two types of laser protective inserts for Goggles, Sun, Wind and Dust in quantities suitable for meaningful field tests by military personnel. Our intent was to design and produce an environmentally robust insert that was easily deployed and used under field conditions to provide eye protection against certain laser wavelengths.

1.1 TYPE A ORANGE FILTERS

A total of 600 Type A orange filters cut to fit Goggles, Sun, Wind, and Dust were delivered to the US Army Natick RD&E Center on 4 August, 1992. These met all contractural obligations except for the photopic requirement and resistance to decontamination fluid (household bleach). The photopic transmission averaged 44% compared with the 45% minimum called for by the contract. After 24 hours contact with 5.25% sodium hypochlorite solution, the insert lost much of its abrasion protection, but retained its optical density.

1.2 TYPE B NEAR INFRA-RED FILTERS (NIR)

Because of funding limitations, only 340 of the specified 600 finished filters were manufactured. After inspecting and testing, a total of 275 were delivered on 20 May, 1993 directly to MKI, Inc. of Dumfries, VA at the request of Marine Corps Systems Command. These measured substantially below the contract minimum photopic transmission of 25%. In addition, optical distortion was excessive because of difficulties encountered in the compression molding process, and dye uniformity was poor due to inadequate mixing during compounding. Abrasion protection deteriorated in contact with sodium hypochlorite solution, and there was a loss of coating adhesion after 200 hours of simulated solar exposure.

Type B lenses met contractual requirements for laser and spectrophotometric optical density, haze, abrasion protection, initial adhesion, and chemical resistance to gasoline, kerosene, insect repellent, and brake fluid.

2. INTRODUCTION

This report describes the processes, materials, test procedures and test results developed for laser eye protection goggle inserts.

The contract called for construction of 600 each of two types of thin filters inserts (0.030 inches thick), cut or formed in the shape of the standard polycarbonate ballistic insert for the Goggle, Sun, Wind and Dust. Type A (orange "blue-blocker") filters were to provide protection from 400 to 532 nm, and Type B (near infrared, NIR) filters would protect against lasers operating from 694 to 1064 nm. These filters were to be snapped into place in back of the standard ballistic insert in the frame of the standard Goggle, Sun, Wind and Dust.

Used alone, Type A would provide protection against lasers at the blue end of the spectrum, while Type B would protect against red and near infrared lasers. The two types might be stacked together to provide extended coverage.

3. MATERIALS

3.1 POLYCARBONATE MOLDING RESIN

For both types of filters a blend of commercially available resins was selected for ease of thermal compounding, relatively low molding temperatures and good flexural properties.

3.2 DYES

3.2.1- Orange- A commercially available 1,4 dihydroxy anthraquinone dye (Morton International's Morplas Amber) was used to provide protection in the 400 to 532 nm region.

3.2.2- NIR- To provide broad protection from 694 to 1064 nm, it was necessary to employ a blend of several Polaroid proprietary absorptive dyes of the metal dithiene and phthalocyanine types. These were selected for their relatively good thermal stability, compatibility with polycarbonate resin and specific spectral characteristics. Some of the dyes required considerable effort to develop practical synthesis and extraction techniques, and one of them required purchase and installation of special effluent control facilities to handle a noxious by-product generated during the synthesis of an intermediate.

3.2.3- Ultra-violet absorbers- In order to protect the polycarbonate from actinic degradation, two commercially-available UV absorbers were incorporated in both types of filters. These are Ciba-Geigy's Tinuvin 326 and Cytek's Cyasorb UV 3638.

3.3 ABRASION-RESISTANT COATING

To provide adequate protection against abrasion, a proprietary UV-curable coating (CC-102) was applied to the molded polycarbonate by the Coating Design Group of Milford, Connecticut. The particular coating was chosen because of its superior flexibility as well as its excellent abrasion protection.

4. PROCESSES

4.1 COMPOUNDING

The polycarbonate molding materials were prepared for Polaroid by Coz Chemical Co. of Northboro, MA. Polaroid supplied both the dyes and polycarbonate plastic for blending. The dyes and processing additives were tumble blended with the polycarbonate and then extruded into strands prior to cutting to pellet size for molding. A low shear twin screw extruder operating at temperatures not exceeding 232 °C was used to flux the polycarbonate and permit the dyes to dissolve in the plastic without decomposition. Because of incomplete NIR dye dispersion revealed in the subsequent compression molding operation, it would be necessary to repeat this extrusion operation for future plastic/dye mixtures destined for compression molding. Injection molding, on the other hand, should provide the required additional mixing in the screw of the molding machine.

4.2 MOLDING

Two types of molding processes were used. For the Type A filter, an injection compression molding technique was employed. Conditions were optimized to provide negligible distortion, optical flatness, good thickness control and minimal residual stress. These Type A molding operations were carried out by Optical Systems Technology of Billerica, MA., a firm that has considerable polycarbonate low-stress molding experience.

Because of the limited quantity of NIR dyes available, it was necessary to use a vacuum compression molding technique for the Type B filter. This compression molding technique provided a much more efficient use of materials than the injection compression method. It also permitted lower operating temperatures and therefore minimized the possibility of thermal degradation of dye.

The number of vendors with the appropriate compression molding equipment was limited. We worked with two companies. The first, Fresnel Optics of Rochester, NY, was abandoned after substantial effort because they were unable to control temperatures well enough. The second vendor Cesaroni Technology of Scarborough, Ontario, provided better temperature control but experienced considerable difficulty with thickness control and was unable to produce completely distortion-free parts. Because of time, material, and budget limitations, these difficulties were not overcome.

4.3 HARD COATING

The Coating Design Group of Milford, Connecticut was chosen for applying the abrasion-resistant coating because of its experience in coating flexible filters. Coating flexibility was an essential requirement because of the thin nature of the filter (30 mil) and the harsh use contemplated. The coating solution itself was obtained from SDC Coatings, Inc. of Anaheim, CA, a company that specializes in siloxane chemicals for use as protective coatings. The coating was applied via a "flow coating" technique and was cured by means of UV radiation.

During the contract period we started to qualify Fosta-Tek Optics of Leominster, MA as an alternate hard coating vendor who uses different chemistry and coating techniques. Time and budget limitations prevented us from completing this qualification.

4.4 CUTTING

Two cutting methods were employed to cut the filters to a shape suitable for quickly attaching to ballistic goggles.

One was laser cutting using an 850 watt CO_2 laser. The flat molded sheet was mounted on an X-Y table that was computer controlled for cutting the required shape. The cutting time using this method was approximately 30 seconds per insert. This operation was performed by Laser Services of Westford, MA.

The second method was mechanical milling. With this method, a computer controlled router blade did the cutting at about the same rate as the laser cutting method. This work was done by Pulsar Engineering of Topsfield, MA.

A third method was considered but not tried. This involves the use of a high quality hardened steel die to stamp out the parts. This system is thought to be inherently faster, but the initial tooling cost is substantial. This approach would probably be justifiable only for large volume production.

5. TESTING AND MEASUREMENT METHODS

5.1 SPECTROPHOTOMETRY

For measuring optical density and photopic transmission, a dual beam spectrophotometer was used. For the orange inserts we used a Perkin-Elmer Lambda 9. Photopic measurements were made using illuminant C weighting factors from 380 to 780 nm.

For the NIR filters, we had to switch to a Hitachi 4001 spectrophotometer because the Lambda 9 was not available. Crossover testing indicated the Hitachi measured 0.3 lower in optical density and 1.5% higher in photopic transmission.

5.2 LASER OD

These measurements were made by Montana Laser Optics (now Big Sky Laser Technologies) of Bozeman, Montana. The measurements were made at a fluence level of 20 mJ/cm^2, a spot size of 10-13 mm, 20 Hz repetition rate, and a 10 ns pulse duration. Their precision is +/-0.1 optical density (OD) traceable to NIST (National Institute of Standards and Technology).

5.3 ENVIRONMENTAL TESTING

5.3.1 Hot Storage- Unprotected samples were placed in a Blue M Pro-Set II forced draft oven maintained at 71 °C for 72 hours as specified by MIL-STD-810E, Method 501.2, Procedure I.[1] After equilibration at room temperature, the samples were remeasured as in 5.1, examined visually, and also retested for adhesion and abrasion (10 wipes with fine steel wool under a 500 g load).

5.3.2 Cold Storage- Similarly, another set of samples were exposed to -29° C for 72 hours as required by MIL-STD-810E, Method 502.2, Procedure I[1] in a Model 1004-12GX Blue M refrigerator. Remeasurements were performed as in 5.3.1.

5.3.3 Tropical Cycle- Using an Environmental Systems Co. Climate Chamber Model HB/4, samples were exposed to 240 hours of alternating cycles 4 and 5 as described in MIL-STD-810E, Method 507.2, Procedure I[1]. The samples were remeasured as in 5.3.1.

5.3.4 Solar Radiation- Samples were placed in an Atlas Ci35A weatherometer for a total of 240 hours as specified in MIL-STD-810E, Method 505.2, Procedure II[1]. This test consisted of 10 24-hour cycles using 0.35 $W/m^2 \cdot nm$ @ 340 nm and 48 °C air temperature during the 20 hour light cycle and a 25 °C air temperature during the 4-hour dark cycle. Humidity was not controlled but fluctuated with the ambient air dew point and dry bulb temperature.After exposure, the samples were retested as in 5.3.1.

5.4 OPTICAL DISTORTION

Samples were visually compared with the distortion standards of MIL-SPEC- V43511C[2] using an Ann Arbor Co. Series E Optical Distortion Tester with a 50-line grating.

5.5 PRISM AND POWER

A Humphrey-Allergan Model 340 Lensometer was used to measure prism and power in the eye-centered section of the filters.

5.6 HAZE AND ABRASION

Samples were subjected to 50 cycles under a 500 g load on a Model 503 Taber Abraser using CS10F Calibrase wheels. Haze of abraded and unabraded areas was measured on a Gardner Spectrogard II Colorimeter using Illuminant A.

5.7 ADHESION

Samples of stored and unstored filters were tested for hard coat adhesion using the knife adhesion method described in ASTM D3359-87[3]. This process involves scribing the surface with a six-bladed circular cutting blade, then attaching a strip of pressure-sensitive tape over the scribed area and peeling the tape away at a 180-degree angle. The amount of coating removed, if any, was compared against a standard scale and given a numerical rating.

5.8 CHEMICAL RESISTANCE

Strips of hard coated filters were partially immersed in the test fluids at room temperature for 24 hours. The samples were then removed, rinsed in 2-propanol, air dried and visually compared with unexposed samples. A change in visual appearance constituted a failure.

5.9 BALLISTIC TESTING

With the filter in place on the outside of a standard clear Goggle, Sun, Wind and Dust a 17-grain 22-caliber pellet was fired to achieve an impact velocity between 540 and 560 feet per second. The test was conducted in accord with MIL-SPEC-V43511C[2] and MIL-STD-662[4] by H.P. White Laboratories of Street, Maryland.

5.10 VISUAL CHARACTERISTICS

The finished lenses were 100% inspected for visual defects using the criteria of MIL-SPEC-G43914D[5], paragraph 4.4.2.1[5] and MIL-SPEC-V43511C[2], paragraph 4.4.3.[2] The filters were examined on both sides in transmitted and reflected light at "arm's length" and in the "as worn" position. The number and type of defects were recorded as a percent of the total inspected.

6. RESULTS

Results are tabulated, summarized and compared against contract requirements in Table 1 for the orange Type A filters and in Table 2 for the NIR Type B filters. Typical optical density vs wavelength curves are shown in Figures 1 and 2. Table 3 summarizes the visual defect analysis for both types of filters. Appendices A and B are the instruction sheet copy furnished with the filters.

TABLE 1.

TECHNICAL DATA SUMMARY FOR TYPE A ORANGE FILTERS

I. Optical Density and Photopic Transmission (Initial and Aged Samples)

(measured on Perkin-Elmer Lambda 9)

Sample No.	Thickness (MIL)	Optical Density at 532 NM			Photopic		
		Initial	Final	Change	Initial	Final	Change
1H	29.0	4.21	4.10	-0.11	43.8	43.8	0.0
2H	28.0	4.22	4.14	-0.08	43.4	43.2	+0.2
3H	27.5	4.22	4.19	-0.03	44.7	44.7	0.0
4C	29.0	4.24	4.21	-0.03	43.7	43.9	+0.2
5C	28.0	4.22	4.19	-0.03	44.1	43.8	-0.3
6C	27.0	4.20	4.21	+0.01	43.7	43.5	-0.2
7T	28.0	4.19	4.18	-0.01	44.5	44.4	-0.1
8T	27.0	4.20	4.20	0.00	44.1	44.0	-0.1
9T	29.0	4.20	4.19	-0.01	44.1	44.1	0.0
10S	30.0	4.21	4.22	+0.01	44.8	44.6	-0.2
11S	29.0	4.23	4.20	-0.03	44.6	44.6	0.0
12S	28.0	4.21	4.19	-0.02	44.0	44.1	+0.11
13X	28.0	4.24			43.8		
Average	28.3	4.21	4.19	-0.02	44.1	44.1	0.0
Std Dev.	0.9	0.02	0.03		0.4	0.5	
Spec.	29.0-31	>4.0	>4.0		>45.0	>45.0	

H= 3 Day/71·C   T = 10 Day/ Cycle 4/5

C = 3 Day/-29· C   S = 10 Day/ Solar

II. Haze (Spec. = < 3.0%)

Ave. of 12 = 1.85%, Std. Dev. = 0.07

III. Taber Abrasion (Spec. = < +6%)

Ave. of 12 = +1.38%. Std. Dev. = 0.19

TABLE 1 *(continued)*

IV. Laser Optical Density (Spec. = >4.0)

5 Samples Measured Greater than 5.0

V. Optical Distortion (Spec. = Level 5 Max.)

11 Samples were Level 1

VI. Prism/Power (Spec.: Power < +/- 0.125 Diopter

Vertical Prism < 0.18 Diopter
Horizontal Prism < 0.5 Diopter)
Range of 11: Power = +0.02 TO -0.05
Vertical Prism = -0.05 TO + 0.07
Horizontal Prism = -0.03 TO 0

VII. Chemical Resistance (Spec. = No Visible Damage)

Brake Fluid - Pass
Gasoline - Pass
Kerosene - Pass
Motor Oil - Pass
Deet Insect Repellent - Pass
Household Bleach - Fail (Attacks hard coating, producing haze and reducing abrasion protection, but without losing optical density).

VIII. Ballistic Test (Spec. = No loss in protection of the standard clear ballistic lens)
The Type A Filter shattered after one shot but the clear ballistic lens was not adversely affected.

IX. Visual Quality (Spec. = AQL OF 6.5 for major and minor defects combined)
Inspection Level I, Sample Size 20, 3 Calls,
Equivalent to 15% Defective = Pass

(See TABLE 3)

TABLE 2.

TECHNICAL DATA SUMMARY FOR TYPE B NIR FILTERS

I. Optical Density and Photopic Transmission (Initial and Ages Samples)

(measured on Hitachi U4001 Spectrophotometer)

Sample No.	Thickness (MIL)	Optical Density @ 694 NM			Optical Density @ 790 NM*			Optical Density @ 1064 NM			Photopic		
		In	Fin	Chg	In	Fin	Chg	In	Fin	Chg	In	Fin	Chg
1H	29.6	5.1	5.1	0.0	4.1	4.1	0.0	4.5	4.5	0.0	14.2	14.3	+0.1
2H	30.7	5.3	5.2	-0.1	4.3	4.3	0.0	4.7	4.7	0.0	13.4	13.3	-0.1
3H	31.1	5.3	5.3	0.0	4.3	4.3	0.0	4.6	4.6	0.0	12.9	13.0	+0.1
4C	31.9	5.4	5.3	0.0	4.5	4.4	-0.1	4.8	4.9	+0.1	12.2	12.2	0.0
5C	33.9	5.5	5.3	-0.2	4.7	4.6	-0.1	4.7	4.8	+0.1	11.2	11.3	+0.1
6C	33.9	5.5	5.5	0.0	4.7	4.7	0.0	4.9	5.2	+0.3	10.9	11.1	+0.2
7T	31.5	5.3	5.2	-0.1	4.4	4.4	0.0	4.6	4.2	-0.4	12.8	12.9	+0.1
8T	30.7	5.3	5.2	-0.1	4.3	4.3	0.0	4.7	4.2	- 0.5	13.2	13.2	0.0
9T	33.1	5.5	5.4	-0.1	4.7	4.7	0.0	4.8	4.2	-0.6	11.3	11.2	-0.1
10S	29.2	5.1	4.7	-0.4	4.0	3.7	-0.3	4.4	4.1	-0.3	14.7	16.5	+1.8
11S	31.9	5.4	5.1	-0.3	4.5	4.1	-0.4	4.7	4.4	-0.3	12.0	13.0	+1.0
12S	33.9	5.8	5.5	-0.3	5.1	4.7	-0.4	4.8	5.0	+0.2	9.4	10.3	+0.9
Ave.	31.8	5.4	5.2	-0.2	4.5	4.4	-0.1	4.7	4.6	-0.1	12.4	12.7	+0.3
Std. Dev.	1.6	0.2	0.2		0.3	0.3		0.1	0.4		1.5	1.7	
Spec.	29-30	>4.0	>4.0		>2.0	>2.0		>4.0	>4.0		>25.0	>25.0	

NOTE: * 790NM = OD Minimum between 800 and 980 NM)

H = 3 Day/71· C　　T = 10 Day/ Cycle 4/5

C = 3 Day -29· C　　S = 10 Day/Solar

II. Haze (Spec. = < 3.0%)

Average of 7 = 1.2 (Std. Dev. = 0.2)

III. Taber Abrasion (Spec. = <+ 6.0%)

Average of 7 = +1.9% (Std. Dev. =0.4)

TABLE 2 *(continued)*

IV. Laser Optical Density (Spec. = >4.0)

Average of 5 at 694 NM = >5.0
Average of 5 at 1064NM = >5.0

V. Optical Distortion (Spec. = Level 5 Max.)
Average of 5 = Level 7

VI. Prism/Power (Spec.: Power < +/- 0.125 Diopter
Vertical Prism < 0.18 Diopter
Horizontal Prism < 0.5 Diopter

Range of 5: Power = -0.09 TO +0.11
Vertical Prism = -0.04 TO +0.06
Horizontal Prism = +0.05 TO +0.10

VII. Chemical Resistance (Spec. = No Visible Damage)
Brake Fluid = Pass
Gasoline = Pass
Kerosene = Pass
Motor Oil = Pass
Deet Insect Repellant = Pass
Household Bleach = Fail (Attacks hard coating, producing haze and reducing abrasion protection, but without losing Optical Density).

VIII. Ballistic Test (Spec. = No loss of protection of the standard clear ballistic lens).

Because of budget limitations,this test was not performed on the NIR Type B filter. However, there is no reason to believe it would perform any differently than the Type A Orange Filter (see TABLE 1)

IX. Visual Quality (Spec. = AQL of 6.5 for major and minor defects combined)
Inspection Level I, Sample size 20, 20 calls
Equivalent to 100% defective = Fail

(See TABLE 3)

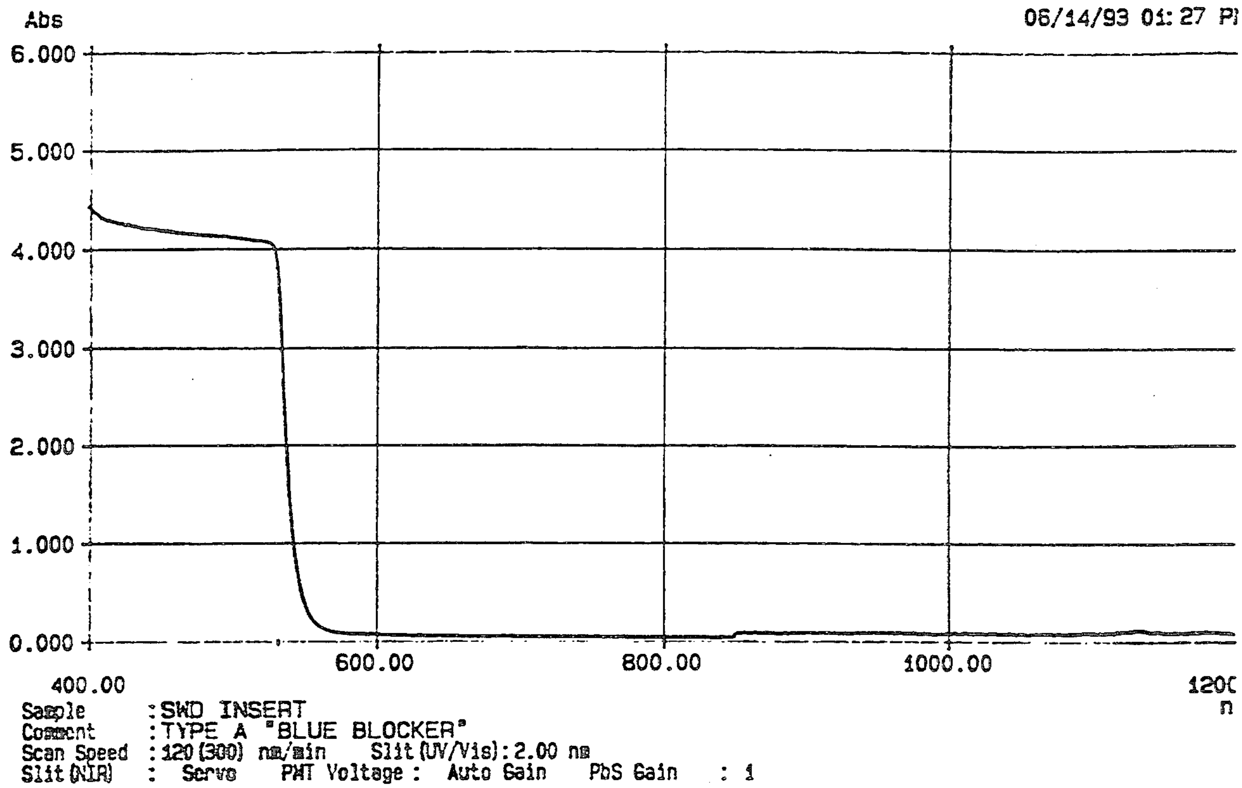

Figure 1. Goggle: Sun, Wind, Dust Insert Type A "Blue Blocker."

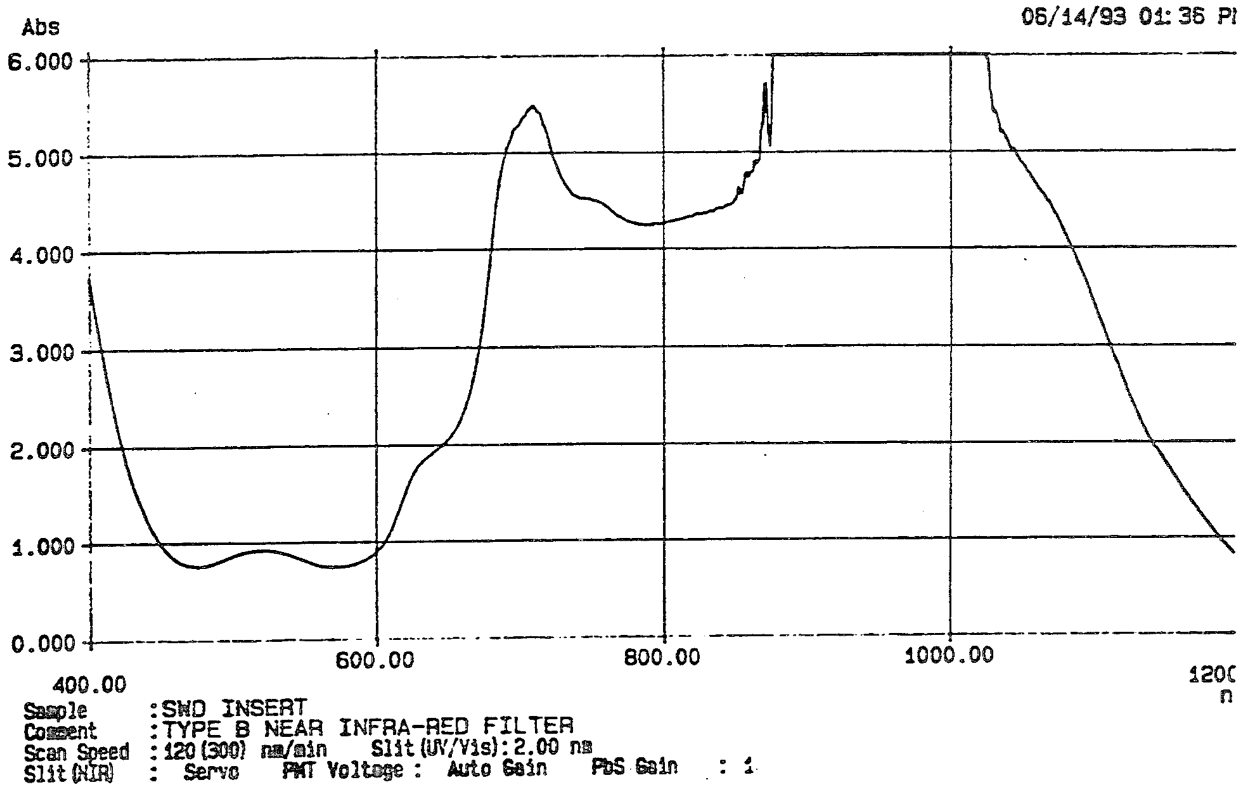

Figure 2. Goggle: Sun, Wind, Dust Insert Type B Near-Infrared Filter.

TABLE 3.

VISUAL DEFECT ANALYSIS

DEFECT	% DEFECTIVE TYPE A ORANGE	% DEFECTIVE TYPE B NIR
SURFACE SCRATCH	5.5	2.6
DISTORTION	4.0	58.2
SPOTS	2.8	17.0
DRIPS	0.3	-
DYE STREAKS	-	100.0
MISCL	2.5	3.5
TOTAL % DEFECTIVE	15.1	100
SAMPLE SIZE	600	340

7. CONCLUSIONS

Several performance deficiencies became apparent during the course of this work.

7.1 TYPE A FILTERS

In the case of the orange filter, the photopic specification of 45% was missed by 1%. The abrasion resistant coating was degraded by contact with bleach. In addition the hard coating process introduced a substantial level of scratching and entrapped dirt. Insufficient dye mixing and incomplete cavity fill during molding gave rise to an unacceptable level of dye nonuniformity and optical distortion. The laser cutting method produced excessively rough edges and excessive vapor redeposition.

7.2 TYPE B FILTERS

With the NIR filter, the hard coating problems of scratches and dirt were overcome, but there was still a loss of abrasion protection after immersion in sodium hypochlorite solution. In addition, there was loss of hard coat adhesion to the polycarbonate, but not abrasion resistance, after solar exposure. This adhesion loss did not occur with the orange filters even though the same hard coating and same grade of plastic was used for both. It is conceivable that added UV protection offered by the orange dye may have contributed to the better adhesion performance of the orange filter.

A more serious problem, however, was our inability to come close to meeting the photopic specification of 25%. Whether there may have been interaction of the several dyes to produce higher than required OD in the 800 to 980 nm region and lower than required transmission in the photopic region remains a subject of future investigations.

In addition to this transmission issue, the other major concern with the NIR filters was the poor dye uniformity and molding quality. We are confident that satisfactory dye uniformity can be achieved by employing multiple passes in the plastic/dye compounding process. The distortion resulting from the compression molding operation may be overcome by reverting to injection molding when a sufficient dye supply is available.

8. RECOMMENDATIONS

Future work should concentrate on the following areas:

1. Improve the dye/plastic compounding process to provide uniform distribution of dyes in the polycarbonate matrix.

2. Explore various dye ratios and loadings for the Type B system to maximize photopic transmission.

3. Investigate alternative abrasion-resistant coatings for improved resistance to bleach and better adhesion after solar exposure. Also, evaluate newly available formulations that combine abrasion resistance with antifog properties.

4. Seek other sources of some of the NIR dyes so there is an adequate supply for future molding trials.

5. Consider injection molding for the NIR system in order to achieve satisfactory optical properties and thickness control.

9. REFERENCES

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APPENDICES

A. Instructions for Use of Orange Type A Filters

B. Installation, Care and Cleaning Inserts

Appendix A

Instructions for Use of Orange Type A Filters

Laser protective insert for for goggles: sun, wind & dust

Safety, care and instruction sheet.

I. General Description

This orange (Type A) laser protection insert provides protection against Double Neodymium (532nm) lasers only.

It is made of polycarbonate plastic, but by itself does not offer ballistic protection. It is to be used with the standard clear ballistic lens in laser threat situations. The clear ballistic lens does not provide laser protection.

II. Safety

This insert may save your eyesight!

Warning

The orange insert may change the appearance of and possibly eliminate some green and blue light sources.

Caution

If lased, do not stare at the laser source. Some lasers have additional wavelengths that may not be filtered by this insert and may cause eye damage.

Caution

The insert is not intended to provide protection against bright light. Do not use it to view solar eclipses, electric welding, torch welding, burning, cutting, and other potentially eye damaging light sources.

Caution

Laser protection levels are reduced if used with binoculars and any magnifying sighting devices.

Caution

Inserts are not to be used as a substitute for other types of laser protection. Protection during maintenance or servicing of specific laser systems should be as specified by the appropriate manual.

Note

Inserts reduce the ambient light levels available to the eye. When starting to wear inserts, the eyes should be allowed to adjust prior to operations, especially at dawn or dusk.

Note

Excessive scratching may degrade the laser protection of the insert. Clean according to instructions only. Turn in insert with an excessive number of scratches or any deep scratches.

Note

Unnecessary sunlight exposure should be avoided because long periods in the sun may reduce the laser protection provided by the inserts.

Appendix B

Installation, Care and Cleaning Inserts

Installation & replacement

To attach insert

1 Clean both surfaces of the clear ballistic lens with water and wipe dry with a clean soft cloth or paper.

2 Unsnap both buttons of the goggle holder but leave the lens attached to the rubber frame. (Sliding a coin or knife under the rubber lip near the snap helps release the snap.)

3 Clean both sides of the insert with water and wipe dry with a clean soft cloth or paper.

4 While seated, place the top of the goggle against the top of the thigh.

5 Slide the top of the insert under the top rubber lip all the way out to the strap area.

6 Starting at the bottom snap, peel the bottom rubber lip away from the lens, and using thumb and forefinger, roll the lip over the edge of the insert, working from the snap area out to the strap area. Do one side at a time.

7 Resecure the snaps by placing a finger against the inside of the snap and applying force to the outside of the snap using a thumb or a hard flat surface.

8 Remove fingerprints from the insert by moistening with water and wiping dry with a clean soft cloth or paper.

9 If a second insert is required, repeat steps 2 through 8.

To remove insert

1 Release bottom snap and peel bottom lip away from lens.

2 Slide fingernail and/or finger under the insert and pull down. The insert should easily slide away from the top snap.

Care of insert

- The plastic insert is flexible and lighter than glass.
- When it is not in use, protect it from sand, dirt, or hard objects. To make it last longer, keep it in a dry place out of direct sunlight.
- Avoid contacting the insert with harsh chemicals like acids, alkalis, or bleach. These chemicals may attack the insert and affect visibility.

Cleaning instructions

- Wash with mild soap, detergent and water.
- Rinse in clear water.
- Air dry or pat dry with a clean soft tissue or cloth.

Do not use ammonia, alkaline cleaners, abrasive cleaning compounds, bleach, solvents, gasoline, bore cleaner or hot water.

Dust and fingerprints may be removed by breathing on the insert, then wiping it dry with a clean cloth or soft tissue or toilet paper, making certain that the cloth, tissue or paper is free of grit, sand or dirt.

Use it – don't abuse it

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