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INSTITUTE REPORT NO. 445

Field Evaluation of Laser Protective Eyewear

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DA Stamper,
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and
BE. Stuck

Division of Ocular Hazards Research

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Human Subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Reg 50-25 on the use of volunteers in research.

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William C. Cobb 10 Jan 90

for DONALD G. CORBY (date)
COL, MC
Commanding

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A group of seventy soldiers at the National Training Center were issued Ballistic and Laser Protective Spectacles (B-LPS). The soldiers were surveyed after 90 days of B-LPS use, and again after 180 days. A pencil and paper inventory addressing durability, compatibility, and acceptability was administered at both 90 and 180 days; in addition, a photographic analysis of fit was performed at the 90 day point. Results indicated good overall acceptability and excellent durability. Problem areas were identified as susceptibility to abrasion from dust, lack of protection against blowing dust, and incompatibility with the PASGT and CVC helmets. Recommendations for design changes are suggested.

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ABSTRACT

A group of seventy soldiers at the National Training Center were issued Ballistic and Laser Protective Spectacles (B-LPS). The soldiers were surveyed after 90 days of B-LPS use, and again after 180 days. A pencil and paper inventory addressing durability, compatibility, and acceptability was administered at both 90 and 180 days; in addition, a photographic analysis of fit was performed after 90 days. Results indicated good overall acceptability and excellent durability. Problem areas were identified as susceptibility to abrasion from dust, lack of protection against blowing dust, and incompatibility with the PASGT and CVC helmets. Recommendations for design changes are suggested.

Field Evaluation of Laser Protective Eyewear

George R. Mastroianni, Jeffrey D. Gunzenhauser, David A. Stamper, Kathryn H.M. Knudson, and Bruce E. Stuck

Widespread recognition of the need for individual protection against the threat of injury from battlefield laser weapons has stimulated considerable research and development effort in both government and industry. The unprotected eye is most vulnerable to the threat from existing systems. Both visible and near-infrared lasers are capable of producing injuries of varying severity, including temporary changes in visual acuity and permanent blindness Infrared lasers can produce painful and debilitating burns.

Research effort has been devoted to developing filters which can be placed in the optical train of sighting systems or worn as spectacles. Such filters are designed to diminish the incident laser energy to safe levels under specified exposure conditions.

Any filter represents a compromise between rejecting enough incident light to ensure safety, but passing enough to allow adequate vision and performance. While research is underway to develop an "ideal" filter, current technology is embodied in a system which has been fielded to serve as an interim solution to the problem of providing individual laser protection. This system, known as the Ballistic and Laser Protective Spectacles (B-LPS), consists of a toroidal polycarbonate eyewrap designed to provide protection against the impact of small projectiles. Issued in both clear and sunglass versions, the kit also includes a laser protective frontsert. A full description of the B-LPS system can be found at Appendix A.

By early 1990, more than 100,000 sets of B-LPS will have been issued to soldiers. Systematic testing of production samples has established that the B-LPS meet required standards of impact resistance and optical quality. As the B-LPS transition from a developmental to an operational system, our research interest shifts from the basic physical characteristics of the device to the more complex interaction between user and system. Accordingly, we conducted a field

evaluation of B-LPS use among some 70 soldiers assigned to the National Training Center at Ft. Irwin.

The aspects of user-system interaction that are of greatest importance when evaluating spectacles are durability, compatibility, and acceptability. Durability is simply the capacity of the B-LPS to resist the debilitating effects of normal wear and tear. Both environmental (sun, dust, moisture) and user-related (cleaning method, frequency of use, care in opening and closing temples) factors may affect our assessment of durability.

Compatibility refers to the interoperability of the B-LPS with the many other items of equipment (helmets, small arms, binoculars) and components of larger systems such as tank sights, aircraft gauges, or control knobs that soldiers are required to use.

We think of acceptability as the enthusiasm soldiers have for using a certain item. Use is one indication of acceptability, but is also influenced by command pressure, availability and permissibility of substitutes, and the soldier's perception of the need for an item. While acceptability is difficult to define and measure, questioning soldiers about their attitudes toward an item often produces insights unobtainable any other way. Moreover, it stimulates soldiers to take an active interest in the equipment with which they are expected to be proficient.

METHOD

B-LPS were issued to more than a hundred observer/controllers at the National Training Center at Ft. Irwin, California. Key personnel (team leaders, first line supervisors) were given a class on the fitting, care and use of the B-LPS by one of the authors. Command guidance for the unit was that either the B-LPS or one of two other forms of eye protection must be worn when operating or riding in tactical vehicles; when downrange during active laser use, laser protection (B-LPS) was required. The other forms of acceptable eye protection were commercially available industrial safety goggles available locally.

After issuing the B-LPS, we had no contact with the soldiers until approximately 90 days later, when we conducted a comprehensive data collection effort. There were two methods of data collection: a questionnaire/interview procedure and a photographic record.

The questionnaire/interview procedure was designed to elicit demographic information, use history, and subjective evaluation of the B-LPS. Durability, compatibility, and acceptability were specifically addressed. The questionnaire completed by the soldiers is reproduced at Appendix B. After reporting to the data collection site, soldiers were asked to sit down and complete the questionnaire. Procedural questions from the soldiers were answered by one of the authors. Upon completion of the questionnaire, one of the team members interviewed the soldiers individually. The interview was used to solicit additional information about questionnaire responses. For example, if a soldier reported discomfort from wearing the B-LPS, the interviewer attempted to obtain more details about the nature, duration, and possible etiology of the discomfort. Some new information was also collected during the interview: whether or not nosepads and retaining straps were being used, the compatibility of B-LPS with helmets, and an overall assessment of the item.

A professional medical photographer photographically recorded the fit of the B-LPS by taking a frontal and lateral photograph of each soldier wearing his B-LPS. After digitizing landmarks on the photographs, a complex geometric analysis was performed to estimate eye position with respect to the design position. A full description of the method and the positional variability analysis can be found in **Gunzenhauser and Mastroianni, 1989**. (Due to the lengthy and technical nature of this analysis, a separate institute report was devoted to it).

RESULTS

The demographic composition of the sample is presented in Table I. The soldiers comprising the sample were predominantly young armored vehicle crewmen. Table II contains a summary of the respondents' estimates of the amount and adequacy of B-LPS training received. The estimate corresponds generally to the

training provided by the author when the B-LPS were issued. It is apparent from these data and from conversations with the soldiers that when unfamiliar items such as these are issued, members of the receiving unit are not likely to take it upon themselves to conduct extensive training on these items.

Table III lists the soldiers' estimates of the amount of time they actually wore their B-LPS during the 90 days of the study. There was considerable variation across members of the unit in B-LPS use, since B-LPS use was largely self-determined. Some members never wore them, while others wore them all day, every day while in the field. The self-reports presented here can only be considered a crude estimate of the use history associated with the B-LPS, since no daily records were maintained by the soldiers; the estimates were made only after the fact.

DURABILITY

Table IV contains the responses to the items concerning durability of the B-LPS. The B-LPS proved to be remarkably resistant to breakage; only five instances of actual breakage were documented. Two of the five breaks involved cracks in the laser frontsert, two involved the temple and one involved a nosepiece. Lack of reliable data precludes an accurate estimate of the ratio of breaks to person-hours of use.

While breakage did not prove to be a problem with the B-LPS, the harsh desert environment caused a significant problem for the B-LPS: abrasion. Both wind-blown sand and debris and dust on the spectacles during cleaning apparently contributed to the degradation of the lens surfaces. More than two-thirds of the users reported significant scratching of the B-LPS, though relatively few noted any change in visibility over time. Inspection of the B-LPS used in the test confirmed that they are indeed highly susceptible to scratching. We recovered several sets and subjected them to laboratory analysis to document the physical deterioration observed. In general, laser protection was not compromised by the scratched frontserts. An overall decrease in transmission was noted in some of the highly scratched items we recovered, however, indicating a potential for degradation of visual per-

formance, particularly under low light levels. Details of these measurements can be found in Appendix C.

No measures of visual performance were made with the soldiers at NTC; however, we measured visual acuity and contrast sensitivity in our laboratory using scratched and unscratched B-LPS. We found no effects on Snellen acuity, but we did observe a slight loss of contrast sensitivity at the highest spatial frequencies. This degradation might have an impact on visual performance requiring the perception of fine detail, but such an assessment would require further evaluation. A summary of the analysis can be found at Appendix D.

Several samples of scratched B-LPS were also examined for the presence of haze. Haze levels were significantly higher in scratched samples than in new B-LPS. While subjective reports of visual disturbance were not common among the troops, the presence of measurable differences in haze emphasizes the need for continued monitoring and analysis of such eyewear systems as they come into wider use. The analysis is summarized in Appendix E.

In addition to the scratching caused by the environment, two features of the B-LPS construction also caused scratching. Most soldiers used the tubular elastic retention strap provided with the B-LPS. When this retention strap is not installed, the tips of the bows rub against the inside surface of the eyewrap, causing a small area of abrasion. These spots are typically located fairly near the design eye position.

Another problem relating to the B-LPS construction is the scratching caused by the rim of the lens carrier (prescription insert) on the inner surface of the eyewrap. Since the scratching occurs outside the normal field of view, this problem is less serious than the temple-bow scratching.

A final source of scratches appears to have been the tight fit between the cases issued with the B-LPS and the eyewrap themselves. Sliding dusty B-LPS into dusty cases caused scratches in the upper nasal quadrant of each side of the eyewrap. Some soldiers recognized this problem and attempted to correct it by

wrapping the B-LPS in rags before placing the eyewrap in the case.

An improved carrying case was issued to the soldiers at NTC after 90 days of B-LPS use. The original case was a soft plastic case providing a somewhat snug fit for the B-LPS and retention strap. While no systematic attempt was made to document use of the kinds of cases, comments were solicited from users at the 180-day data collection (after 90 days of use). The new carrying case, of rigid plastic construction, was generally considered superior to the older, soft-plastic version. Most soldiers seemed to think that the new case was a better fit for the B-LPS, and that the new case lessened the deleterious effects of the dusty environment. Another advantage of the new case is that it provides better protection against accidental crushing or impact damage when the spectacles are stored.

COMPATIBILITY

Table V contains the results of the questionnaire items pertaining to compatibility. Our ability to make generalizations based on the information we collected is limited by the variety of systems used in conjunction with the B-LPS. The systems used included the HMMWV, the M-551 Sheridan Armored Reconnaissance Vehicle, the CUCV, the M-881 Recovery Vehicle and various items of individual equipment such as the PASGT (Kevlar) helmet, the Combat Vehicle Crewman (CVC) helmet, and unit level communications and visual surveillance equipment.

There were few reports of visual function impairment sufficient to impede the accomplishment of any tasks with the B-LPS. Of such reports, most related to the scratching of the B-LPS or the failure of the B-LPS to protect the eyes against dust. Readability of dials and gauges was not compromised by the B-LPS. Problems were reported in two important areas: the use of optical devices such as binoculars or vehicle sights, and wear of both the PASGT and CVC helmets.

The shape of the B-LPS eyewrap causes a considerable axial distance between the eyes and the front surface of the eyewrap. (The average distance appears

to be approximately 2 cm.) This distance adds to eye relief from optical devices, resulting in both restriction of the field of view and discomfort from the nosepieces pressing on the bridge of the nose. The reduction in field of view caused by the B-LPS has been documented for one system (the TOW) in a separate report. (See Campbell and Mastroianni, 1989)

This axial distance also contributes to the compatibility problems observed with the PASGT helmet. For some soldiers, the visor of the helmet makes contact with the upper edge of the eyewrap as the head moves or is jostled by vehicle movement, causing pain as the B-LPS are driven down on the bridge of the nose.

The problems reported by some soldiers using the CVC helmet are caused by a different mechanism. In this case, the temple bows of the B-LPS are compressed by the CVC earcups. This leads to discomfort as the bows are pressed against the side of the head, and also prevents the earcup from making a good seal against the head, thereby compromising effective hearing protection.

ACCEPTABILITY

Soldier acceptability of the B-LPS was quite variable; some liked them very much, while others detested them. Very few comments relating to the esthetic aspects of the design were made; either the appearance is not of importance to the soldiers, or the appearance was acceptable enough to elicit no comments. Table VI lists the responses to acceptability questions. One common complaint about the B-LPS was that in neither the sunglass version nor the laser frontsert is the tint dark enough for use in the bright desert environment. Some soldiers even reported wearing the laser frontsert over the sunglass version to gain additional sun protection.

Perhaps the most common complaint that soldiers had about the overall acceptability of the B-LPS was that they failed to provide any protection against the blowing sand and dust. Because of the long axial distance, there is considerable opportunity for dust to blow in around the sides of the eyewrap. This characteristic was perhaps the most serious defect of the B-

LPS in the eyes of those soldiers who were dissatisfied with the system.

Table VII lists the results of several rating scales the soldiers were asked to complete giving their evaluation of several general features of the B-LPS, such as clarity, visibility, glare and the like. As can be seen, these ratings were extremely positive.

Our observations seem to indicate good acceptability of the B-LPS in terms of appearance and optical/visual characteristics. In the environmental conditions prevailing at Ft. Irwin, however, the lack of dust protection significantly diminished the enthusiasm of a majority of the interviewed soldiers for using the B-LPS.

DISCUSSION AND CONCLUSIONS

The data we gathered at the National Training Center has provided significant insight into the direction for development of laser protective eyewear. It is clear that more attention must be paid to those features of the eyewear that the soldier will be evaluating each and every time the items are removed from their case and put on - features such as fit, comfort, protection from non-laser environmental hazards (sun, dust) and even appearance.

While the complexities of photopic transmission, optical density at design wavelengths, solarization resistance and the like are critical components of the design process, soldiers take for granted that the eyewear will perform its function when and if it is ever exposed to a laser. If the eyewear does not satisfy the soldier's <u>everyday</u> requirements for comfort, dust protection, and the like, all the technical expertise devoted to the design of the laser protection may be wasted if the soldier chooses not to wear the item.

We must bear in mind that the data reported here are specific to a particular unit, mission, and location. Many of the aforementioned defects will not be a problem in geographical areas free of the exceedingly harsh desert conditions found at Ft. Irwin. The bright sun, dust and high winds led to a complex of problems

that are probably very different from those which might be reported by troops operating in a different environment. Troops serving in Western Europe, for example, might be more concerned about fogging of the lenses and compatibility with cold weather garments.

Notwithstanding the limitations of the results reported here, several specific recommendations about possible design changes are apparent. First, we should ensure that the coating applied to the polycarbonate to increase resistance to scratching is the best available. If the scratch resistance cannot be improved (and it probably cannot) then sufficient quantities of B-LPS should be made available to permit periodic replacement of worn items, based on the expected life of the item in each geographical area. Our data suggests that two or three sets per soldier per year might be appropriate in a desert environment.

Second, we should consider ways to reduce the axial distance, such as redesigning the nosepiece. At least for emmetropes, the metal pad arms and nose pads could be completely eliminated and a universal bridge adopted. In addition to solving some of the breakage problems, this modification would bring the eyewrap much closer to the face. Such a change could improve the dust protection offered by the B-LPS, but might also produce the unintended and undesired result of causing more lens fogging. Thorough testing obviously should be a part of any redesign effort.

Third, we should redesign the temples to offer the option of better compatibility with the CVC helmet. A flatter temple bow could eliminate the current discomfort experienced by CVC users. Another possibility could provide a substitute temple consisting of an elastic strap and appropriate attaching piece for soldiers required to use a helmet.

Finally, we should take action to reduce the number of optical surfaces present to collect dust, fog or other particles. The current design requires six surfaces - the front and back of the frontsert, the front and back of the eyewrap, and the front and back of the prescription lens (for those requiring a prescription). All six of these surfaces collect dust with the present design. Integration of the laser

protection into the sunglass version, for example, would eliminate the need for two of the surfaces. This would also have the beneficial effect of reducing the frequency of cleaning required, itself a significant source of scratching. Of course, the combined sunglass/laser protection would require adequate transmission for nighttime use and adequate attenuation for daytime, sunny use; such a configuration may be difficult to achieve in practice. The desirability of the result should impel us to explore this possibility, however.

Future studies should aim for both functional and geographic diversity in the troop populations studied. Compatibility, especially, can only be adequately assessed when the widest possible range of occupations, equipment, and missions is included in the test program. Full documentation of both positive and negative design features will best support not only improvement of this specific product, but development of systems for other applications and all future protective eyewear.

ACKNOWLEDGEMENTS

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DEMOGRAPHICS

N=70

RANK	N
E1-E4	33
E5-E8	19
O1-O5	17

Average Years in SSI - 6 yr
Average time in unit - 1 yr 7 mo
Wear spectacles - 29
Wear contacts - 12
Average age - 27.3 yrs

TABLE I

Duties include:

Looking through magnifying optics	25
Reading gauges	34
Reading dials	25
Searching for targets	43
Other	14
No response	10

All respondents were assigned to NTC

TRAINING HISTORY

N=70

Average reported length of training - 15 minutes
Number reporting no training - 16

Rating of instruction received: (%)

	Assembly of BLPS	Care of BLPS
Adequate	79	81
Inadequate	17	14
No response	4	4

TABLE II

All respondents assigned to NTC

REPORTED USE HISTORY

N=70

Hours of Use (Last 90 days)

Average day	6.0	Range 0 - 12
Average night	1.4	Range 0 - 6
Last 24 hrs (daylight)	30 min	
Last 24 hrs (night)	0	

15 Soldiers reported never wearing B-LPS

TABLE III

All respondents assigned to NTC

DURABILITY
N=70

Question	Response Y	N	NR
1. Did you experience any breakage	13	76	11
2. Were BLPS easily scratched	61	27	11
3. Notice any visibility change	17	70	13

4. How frequently did you have to clean the BLPS

5 or more times per day	53
2 to 4 times per day	23
Once a day	4
Once every 2 or 3 days	0
Once a week	0
Less than once a week	7
No response	13

Y=YES N=NO NR=NO RESPONSE

TABLE IV

COMPATIBILITY

N=70

	Y	N	NR	(%)
1. Did BLPS interfere with reading any gauges, dials, etc.	10	74	16	
2. BLPS prevent any vehicle/system task	14	67	19	
3. BLPS degrade any vehicle/system task	26	59	16	
4. Did BLPS interfere with mission	11	70	19	
5. Use BLPS with binoculars, vision blks	36	54	10	
6. BLPS cause difficulty with binos, etc	26	20	54	
7. BLPS caused problems with helmets	47	43	10	

TABLE V

Y=YES N=NO NR=NO RESPONSE

ACCEPTABILITY

N=70

TABLE VI

	Y	N	NR(%)
1. Was peripheral vision limited	16	73	11
2. Is tint dark enough (sunglasses)	47	41	11
3. Do BLPS stay in place as you move	73	17	10
4. BLPS uncomfortably hot/cold	9	80	11
5. Do BLPS fog easily	13	74	13
6. Able to use BLPS full 90 days	50	39	11
7. Lose any part of BLPS kit during 90 days	17	71	11

Y=YES N=NO NR=NO RESPONSE

OVERALL RATINGS
N=70

CLEAR EYEWRAP (%)

	VG	G	BL	P	VP	NR
General Visibility	31	50	6	0	1	11
Depth Perception	29	46	7	3	3	13
Peripheral Vision	20	41	13	9	4	13
Clarity	26	41	13	6	0	14
Glare	16	44	17	9	1	13
Object Color	26	44	13	3	0	14

TABLE VII (A)

V=Very G=Good P=Poor B=Borderline NR=No Response

OVERALL RATINGS
N=70

LASER FRONTSERT (%)

	VG	G	BL	P	VP	NR
General Visibility	24	51	6	4	0	14
Depth Perception	21	49	10	3	1	16
Peripheral Vision	17	40	16	7	6	14
Clarity	19	53	11	3	0	14
Glare	20	43	11	11	0	14
Object Color	7	37	27	10	4	14

TABLE VII (B)

V=Very G=Good P=Poor B=Borderline NR=No Response

OVERALL RATINGS
N=70

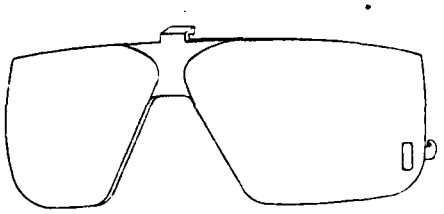
SUNGLASS EYEWRAP (%)

	VG	G	BL	P	VP	NR
General Visibility	24	47	9	1	1	17
Depth Perception	26	49	6	4	1	14
Peripheral Vision	21	36	16	9	4	14
Clarity	20	47	14	4	0	14
Glare	24	40	11	7	3	14
Object Color	10	47	23	4	1	14

TABLE VII(C)

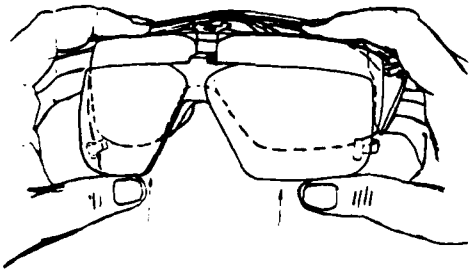
V=Very G=Good P=Poor B=Borderline NR=No Response

IF LASER PROTECTION IS REQUIRED, A LASER PROTECTIVE FRONTSERT IS PROVIDED.

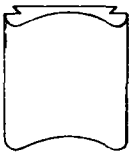


TO ATTACH THE FRONTSERT, SLIDE IT ONTO THE BPU AS SHOWN, CATCHING THE CLIPS AT THE BOTTOM OF THE BPU.

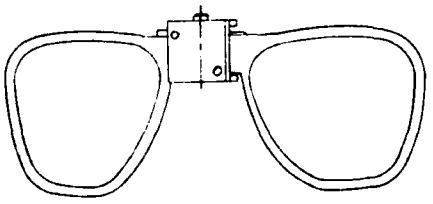
ONCE THE CLIPS ARE PROPERLY CAUGHT ON THE BPU, SNAP THE TOP TAB ONTO THE NOSEPIECE. TO REMOVE, REVERSE THE PROCEDURE.



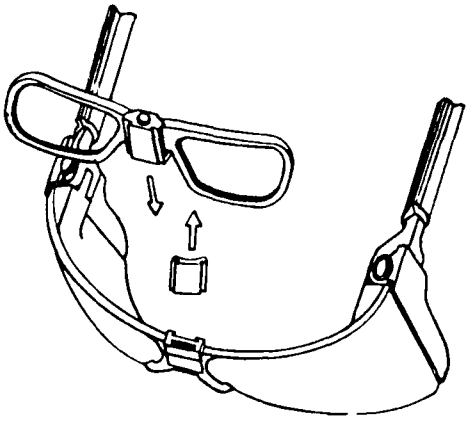
IF YOU DO NOT REQUIRE A CORRECTIVE LENS, A FILLER BUTTON IS SUPPLIED ASSEMBLED TO NOSEPIECE.



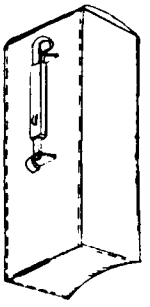
IF YOU REQUIRE CORRECTIVE LENSES, A LENS CARRIER WILL BE ISSUED TO YOU.

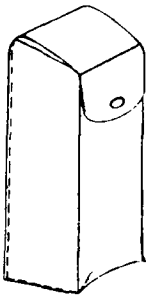


TO ATTACH THE LENS CARRIER TO THE BPE SLIDE THE FILLER BUTTON OUT OF THE SLOT IN THE NOSEPIECE AND REPLACE IT WITH THE LENS CARRIER. THE LENS CARRIER SHOULD REMAIN IN PLACE WITHOUT FURTHER ADJUSTMENT.



THE CARRYING CASE IS DESIGNED TO BE WORN ON THE EQUIPMENT BELT OR IN A BACK PACK. IT WILL ACCOMMODATE BOTH RIGHT AND LEFT HANDED INDIVIDUALS. ALL OF THE COMPONENTS OF THE BALLISTIC EYE PROTECTIVE SPECTACLE SHOULD BE STORED IN THE CARRYING CASE WHEN NOT IN USE





SOLDIER, your PROTECTIVE SPECTACLES SYSTEM is the best available.

It is designed to give maximum field of view with a minimum of distortion and made of polycarbonate. Polycarbonate has proven to be the best material to defeat low-mid velocity fragments from exploding munitions and is used in industrial eye protective spectacles and in the ballistic class 3 and 4 lenses for the sun, wind and dust goggle.

Studies from Vietnam show that casualties could have been reduced 10-15% if eye protective devices of this type were available and worn.

THE PROTECTIVE SPECTACLES SYSTEM IS MADE OF POLYCARBONATE WHICH REQUIRES SPECIAL CARE TO MAINTAIN ITS BALLISTIC QUALITIES.

THE EYEWEAR SHOULD BE CLEANED WITH A SOFT, DAMP CLOTH. IF WATER IS NOT AVAILABLE, STEAM THE LENS WITH YOUR BREATH.

TAKE CARE OF YOUR PROTECTIVE SPECTACLES

DO NOT CLEAN WITH A DRY CLOTH!
DO NOT THROW LENS AROUND OR LEAVE IT WHERE IT MAY BE ABUSED!
DO NOT USE ANY LIQUID OTHER THAN WATER TO CLEAN THE LENS!

USE IT — DON'T ABUSE IT!

AMERICAN OPTICAL CORPORTION
PRECISION PRODUCTS BUSINESS
14 MECHANIC STREET
SOUTHBRIDGE, MASSCHUSETTS
01550-9998

PROTECTIVE SPECTACLES SYSTEM

Record of Hit

Name_____ Serial#_____

Rank_____

Unit_____

Date of Issue_____

Duty Performed When Hit_____

Source of Projectile_____

Date of Hit_____

Estimated Range_____

Continued to Perform Mission? Y☐N☐

Was Injury Sustained? Y☐ N☐

Describe incident_____

FIELD EVALUATION

of

BALLISTIC AND LASER PROTECTIVE

SPECTACLES (B-LPS)

QUESTIONNAIRE

Division of Ocular Hazards
Letterman Army Institute of Research
Presidio of San Francisco, CA 94129-6800

APPENDIX B

App. B - Questionnaire Field Evaluation of Laser Spectacles (B-LPS)

GENERAL:

How old are you? _____ years

What is your date of birth? _____
Day Month Year

What is your rank? __E1 __E2 __E3 __E4 __E5 __E6 __E7 __E8 __E9
__O1 __O2 __O3 __O4 __O5 __O6 __O7 __O8 __O9
__W01 __W02 __W03 __W04

What is your duty MOS? _____ example, 11A

How long have you worked in your MOS? _____ yrs. _____ mos.

How long have you worked in this unit? _____ yrs. _____ mos.

What are the three (3) most important duties which you perform in your unit:

1) _____

2) _____

3) _____

Do your duties include any of the following visual tasks (check any which is/are appropriate).

__ Looking through magnifying optics

__ Reading guages

__ Reading dials

__ Searching for targets

__ Other: _____

_____ _____

_____

_____

Do you wear glasses (spectacles)? __ yes __ no

Do you wear contacts? __ yes __ no

If yes, which type of contacts? __ hard __ soft

App. B - Questionnaire Field Evaluation of Laser Spectacles (B-LPS)

SPECIFIC INFORMATION ABOUT the B-LPS

Who explained the use of the BLPS to you? _____

_____

How many minutes of instructions did you receive on the use of BLPS? __ minutes

Were the instructions you received on how to assemble the BLPS adequate? __ yes __ no

Were the instructions you received on how to care for the BLPS adequate? __ yes __ no

On an average day, over the past 90 days, how many hours have you worn the BLPS during daylight hours? __ hrs

On an average day, over the past 90 days, how many hours have you worn the BLPS during the night hours? __ hrs

During the past 24 hrs how many hours have you worn the BLPS during daylight hours? __ hrs

During the past 24 hrs how many hours have you worn the BLPS during the night hours? __ hrs

Have you ever sustained an eye injury serious enough to require medical attention? __ yes __ no

If yes, describe: _____

_____

_____

_____

_____

_____

App. B - Questionnaire Field Evaluation of Laser Spectacles (B-LPS)

COMFORT:

Are the BLPS uncomfortably hot in the sun? __ yes __ no

Are the BLPS uncomfortably cold in very cold weather? __ yes __ no

Do the BLPS fog easily? __ yes __ no

During an average 1 hr period, how often do you have to wipe fog from the BLPS? __ never __ seldom __ often __ constantly

Was your peripheral vision unduly limited while wearing the BLPS? __ yes __ no

Explain: _____

_____

Is the sunglass tint on the BLPS dark enough? __ yes __ no

Explain: _____

_____

Do the BLPS stay in place as you move around? __ yes __ no

Explain: _____

_____

Do the BLPS rub your nose excessively? __ yes __ no

Explain: _____

_____

Do the BLPS feel uncomfortable in any way? __ yes __ no

Explain: _____

_____

App. B - Questionnaire Field Evaluation of Laser Spectacles (B-LPS)

DURABILITY:

Did you experience any breakage, binding, slipping, or other malfunction with any part of the BLPS? __ yes __ no

If yes, explain and indicate on the diagram to the right where on the BLPS the problem occurred.

Explain: _____
_____
_____
_____
_____
_____
_____

Did you find that BLPS were easily scratched? __ yes __ no

Explain: _____

_____

_____

Did you notice any change in visibility over the time you used the BLPS? __ yes __ no

Explain: _____

_____

_____

How frequently did you find you had to clean the BLPS?

___ 5 or more times a day
___ 2 to 4 times a day
___ Once a day
___ Once every 2 or 3 days
___ Once a week
___ Less than once a week

DURABILITY (cont)

What did you normally use to clean or wipe the BLPS?

Explain: _____

Did you lose any part of the BLPS kit during the time you had it? __ yes __ no

Explain parts lost and other remarks: _____

_____

Were you able to use BLPS for the full 90 days? __ yes __ no

SYSTEM COMPATIBILITY:

Of what vehicle or weapon system are you a crew member?

Explain: _____

What is your crew position? _____

Did the BLPS interfere with your ability to read any gauge, dial, knob, or warning indicator on your system/vehicle? __ yes __ no

If yes, specify: _____

_____

_____

Is there any task relating to the operation of your vehicle/ system that you could not perform while wearing the BLPS? (Example: driving, sighting, getting in/out, etc.) __ yes __ no

If yes, specify: _____

_____

_____

Is there any task you could perform but could not do as well as usual due to the BLPS? (Example: driving, sighting, getting in/out, etc.) __ yes __ no

If yes, specify: _____

_____

_____

MISSION COMPATIBILITY:

What is your combat mission? _____

_____

_____

Do you think the BLPS interefered with your ability to accomplish the your mission? __ yes __ no

If so, how did they interfere with your mission? _____

_____

_____

Did you ever miss a target because you were wearing the BLPS? __ yes __no

Explain: _____

_____

Did you ever become a casualty because you were wearing the BLPS? __ yes __ no

Explain: _____

_____

_____

App. B - Questionnaire Field Evaluation of Laser Spectacles (B-LPS)

Can you imagine any circumstances which you may not have experienced where the BLPS would interfere with your ability to accomplish the mission? __ yes __ no

Explain: _____

_____

_____

Did you ever use BLPS in conjunction with binoculars, vision blocks, optical sights, etc.? __ yes __ no

If yes, did you experience any difficulty in using these items because of the BLPS? __ yes __ no

Explain: _____

_____

_____

App. B - Questionnaire Field Evaluation of Laser Spectacles (B-LPS)

EFFECTS ON VISION (Subjective

Very good = allowed you to function normally without discomfort
Good = permitted normal function with minor discomfort
Borderline = caused some interference with normal function or moderate discomfort
Poor = caused considerable interference of normal function or sense discomfort
Very Poor = caused considerable interference with normal function and severe discomfort

Ballistic Spectacles (clear eyepieces):

General Visibility (check one)

__ very good __ good __ borderline __ poor __ very poor

Depth Perception

__ very good __ good __ borderline __ poor __ very poor

Peripheral Vision

__ very good __ good __ borderline __ poor __ very poor

Clarity

__ very good __ good __ borderline __ poor __ very poor

Glare

__ very good __ good __ borderline __ poor __ very poor

Colors of Objects

__ very good __ good __ borderline __ poor __ very poor

App. B Questionnaire Field Evaluation of Laser Spectacles (B-LPS)

. Laser Spectacles (green frontserts)

General Visibility

__ very good __ good __ borderline __ poor __ very poor

Depth Perception

__ very good __ good __ borderline __ poor __ very poor

Peripheral Vision

__ very good __ good __ borderline __ poor __ very poor

Clarity

__ very good __ good __ borderline __ poor __ very poor

Glare

__ very good __ good __ borderline __ poor __ very poor

Color of Objects

__ very good __ good __ borderline __ poor __ very poor

Sunglasses (brown eyepieces)

__ very good __ good __ borderline __ poor __ very poor

Depth Perception

__ very good __ good __ borderline __ poor __ very poor

Peripheral Vision

__ very good __ good __ borderline __ poor __ very poor

Clarity

__ very good __ good __ borderline __ poor __ very poor

Glare

__ very good __ good __ borderline __ poor __ very poor

Color of Objects

__ very good __ good __ borderline __ poor __ very poor

APPENDIX C

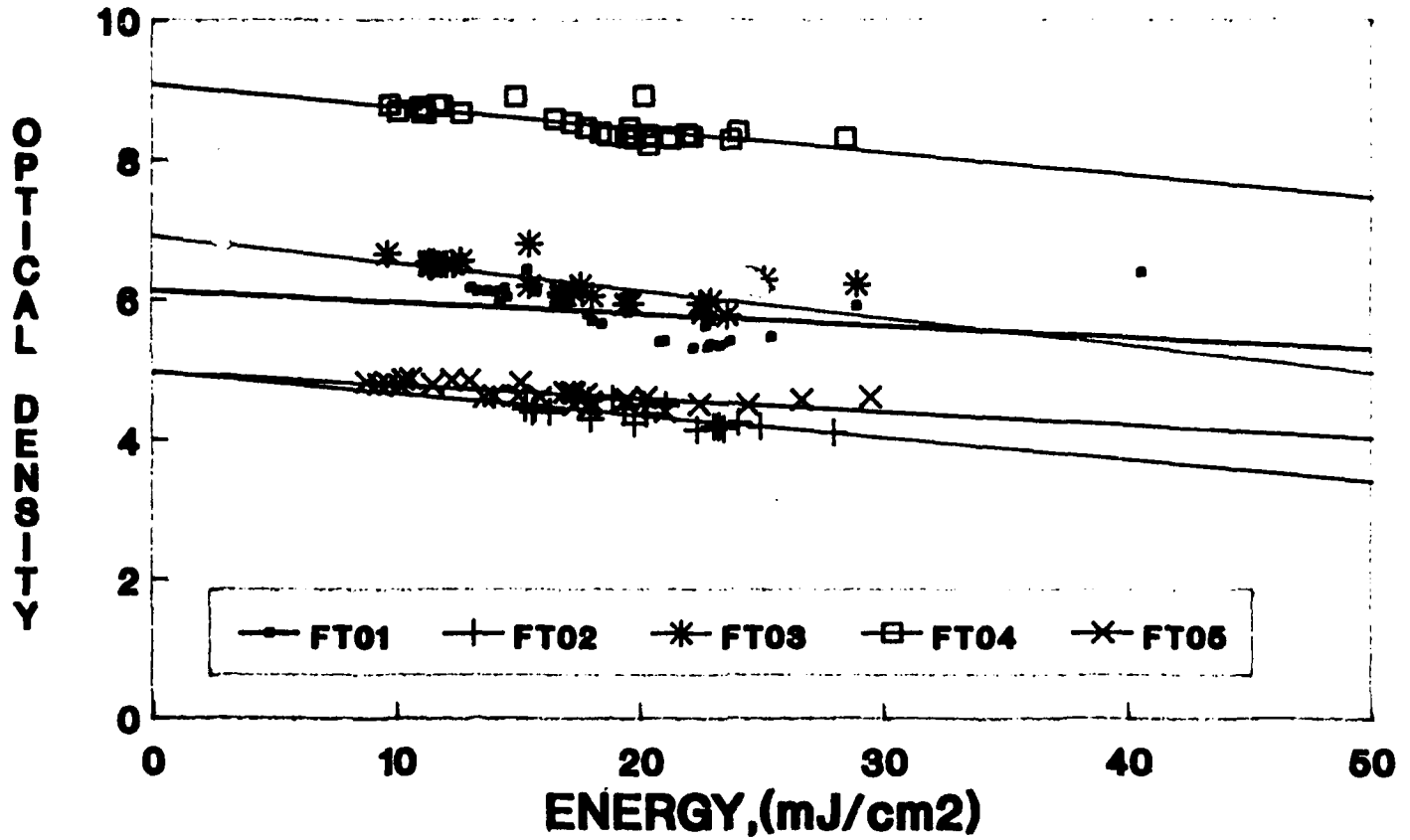
Samples of severely scratched B-LPS were retrieved from NTC and examined in our laboratory. Only the B-LPS that were most severely damaged were used, so the measurements reported here are a "worst-case" analysis.

Two measurements were performed in our laboratory. First, a scratched laser frontsert was evaluated for retention of laser protective characteristics. Figure 1 shows the optical density of scratched frontserts as a function of the amount of Lambda 2 laser energy to which they were exposed. All of the frontserts tested retained sufficient density at the design wavelength to meet specifications, despite the damage they had suffered.

The second test we used measured luminous transmission as a function of wavelength from 300-1300 nm. The frontserts showed a decrease in transmission over the visible spectrum in the scratched area. (See Figure 2) This is apparently due to the reflection and refraction caused by the surface scratches. There was an increase in transmission in the infrared portion of the laser frontsert luminous efficiency function, perhaps caused by loss of the laser protective coating in the scratched areas.

The tinted B-LPS, which have no laser protective coating, showed a general decrease in transmission throughout the 300-1300 nm region in the scratched areas. (See Figure 3) This result is similar to that observed for clear (untinted) B-LPS.

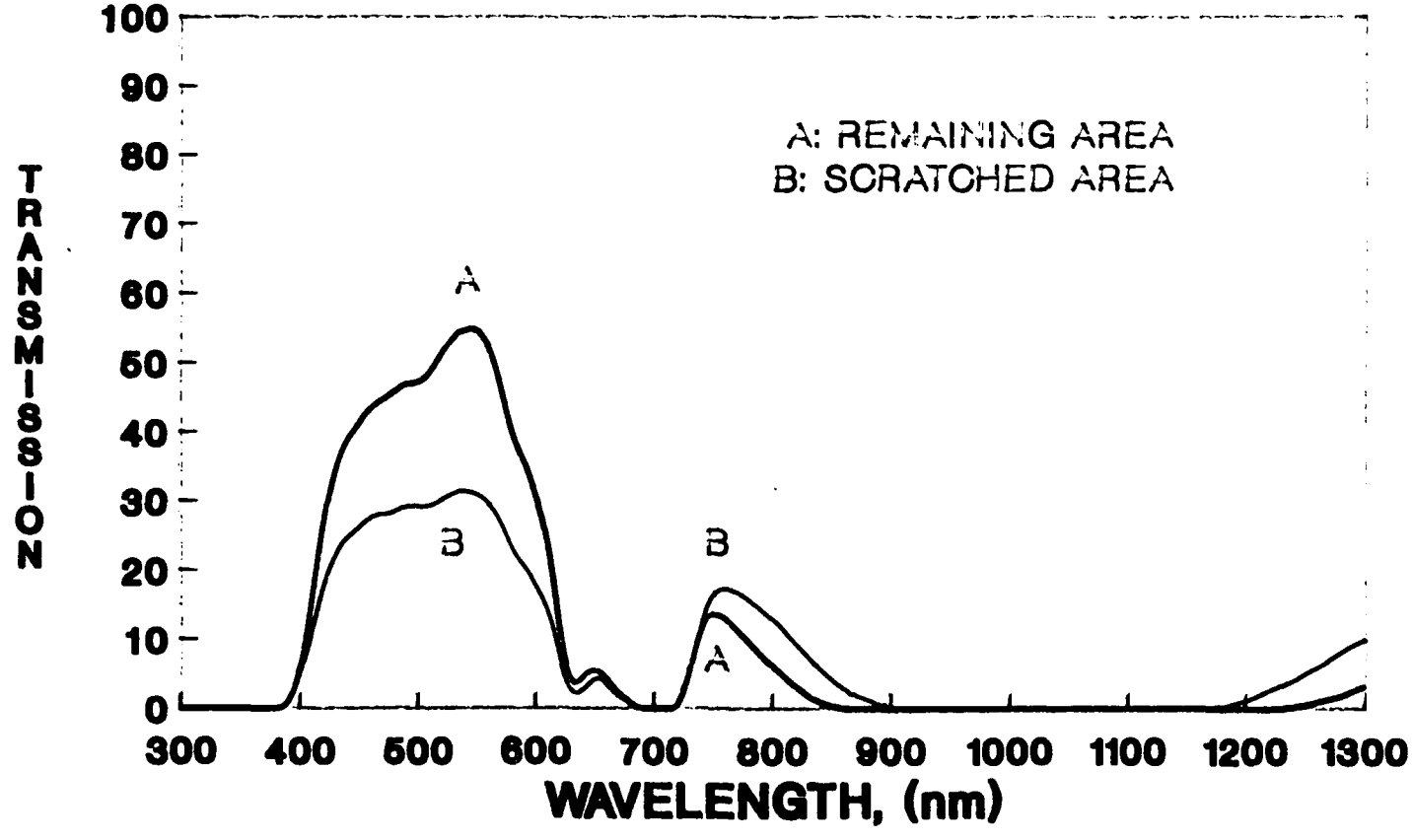
FRONTSERTS,FIELD TESTED
LAMBDA 2



FT04 NOT SCRATCHED

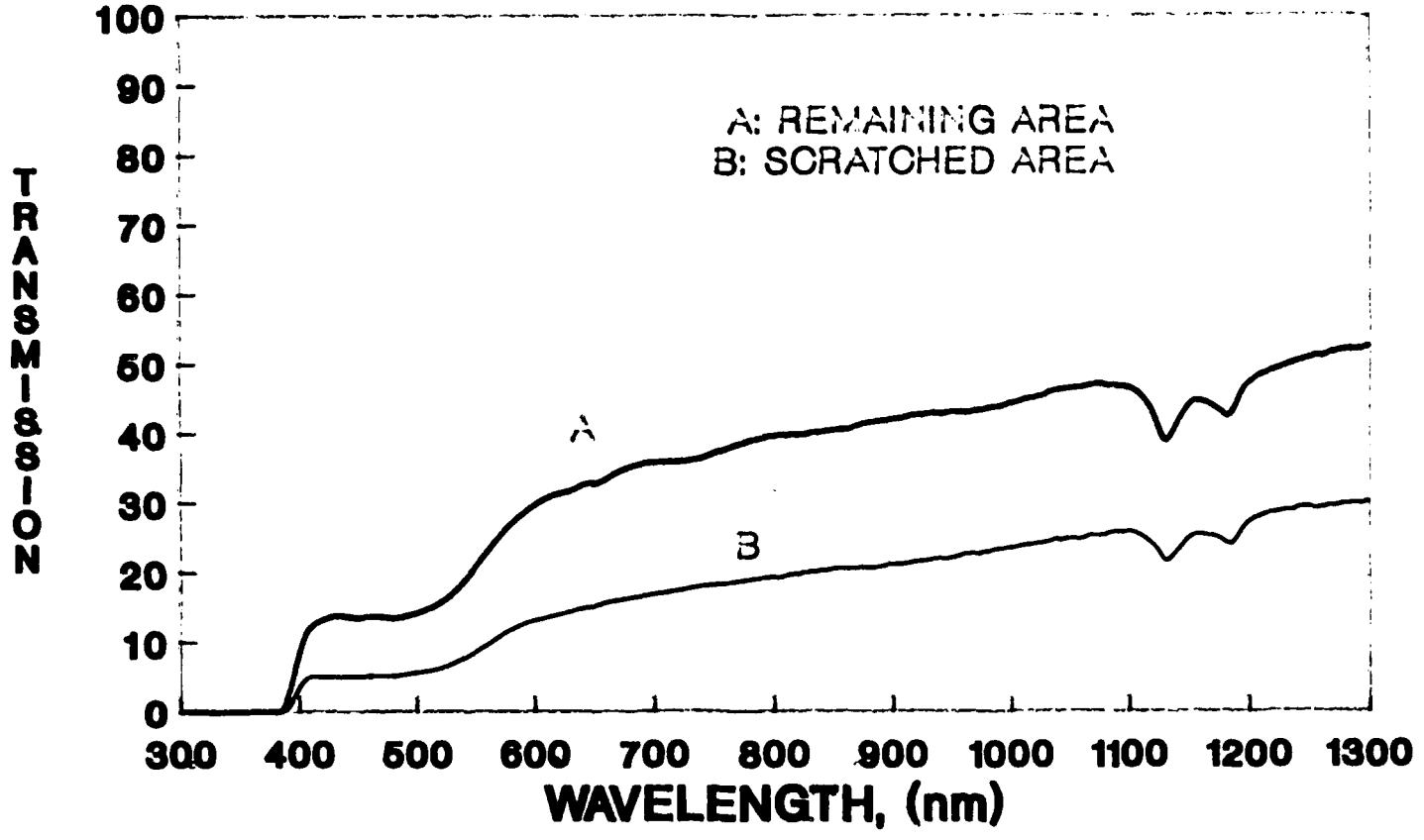
APP C -- Figure 1

FIELD TESTED FRONTSERTS
2 LAMBDA



APP C -- Figure 2

SUNGLASS BLPS
FIELD TESTED



APP C -- Figure 3

APPENDIX D

Brief Studies of Visual Performance Wearing Scratched and Unscratched B-LPS

Study 1

As part of the study of the use of the Ballistic/Laser Protective Spectacles B-LPS), five subjects were asked to read the Snellen Eye Chart (similar to that shown in Example 1) and to read the VISTECH Test of Contrast Sensitivity (similar to that shown in Example 2) under six conditions. The six conditions were: 1) Clear, unscratched B-LPS lenses, 2) Clear, scratched B-LPS lenses, 3) Brown, unscratched B-LPS lenses, 4) Brown, scratched B-LPS lenses, 5) Clear, unscratched B-LPS lenses plus the green (laser) unscratched B-LPS lenses, 6) Clear, scratched B-LPS lenses plus the green (laser) scratched B-LPS lenses. The conditions were presented to the subjects in a random order.

The scratched lenses were obtained from the soldiers at Ft. Irwin whose B-LPS had become scratched in the desert environment and were no longer usable by the soldiers.

The subjects were members of the Letterman Army Institute of Research who did not wear spectacles and who had at least 20/20 vision.

Table I shows the scores on the Snellen for each subject under each condition. Overall, there were five subjects who showed changes when the wear of the unscratched lenses were compared to the wear of the scratched lenses of a similar type.

One subject showed an improvement from 20/15 to 20/10 in the unscratched clear versus scratched clear condition. Three subjects went from 20/15 to 20/20 in the unscratched brown versus scratched brown condition. One subject went from 20/15 to 20/20 in the unscratched green plus unscratched clear versus scratched green plus scratched clear condition. Clinically, there is little reason to believe that these changes would have any significant effect on soldiers' ability to continue their mission in an operational environment.

Table II shows the scores of each subject under each condition for the Contrast Sensitivity Test, line A (wider lines with larger blank areas between the lines). The average to above average range of scores in this area is 5 to 8. All subjects under all conditions scored in this range. There were changes between certain unscratched versus scratched condition; however half were in the positive direction and half were in the negative direction. We are unclear how to interpret these findings; however, for field performance where most visual targets are fairly large, soldiers should have few problems if they were required to use scratched B-LPS.

Table III shows the scores of each subject under each condition for the Contrast Sensitivity Test, line B (lines are not as wide as line A and there are smaller blank areas between the lines than line A). As in line A, the average to above average range of scores is 5 to 8. All subjects under all conditions fell into this range. Subjects showed the following changes between the unscratched versus scratched condition: In going from the clear B-LPS to the scratched clear B-LPS three of the subjects scored one point less in the scratched condition than they had in the clear condition. In going from the clear brown condition to the scratched brown condition, two subjects improved (one by two points and one by one point) and one subject dropped two points in the scratched brown condition compared to the clear brown condition. In going from the laser/clear condition to the scratched laser/clear condition, two subjects improved (one by one point and one by two points) while the other subjects had the same scores under both conditions. Since all scores remained in the normal range, there is little reason to believe that these changes would affect soldiers' performance.

Tables IV, V, and VI show some problems with B-LPS use which at this point is difficult to interpret in terms of wear of B-LPS in operational settings. Lines C, D, and E in the Contrast Sensitivity Test have stimuli that have lines progressively smaller and closer together. With these stimuli soldiers start having more and more scores in both the scratched and unscratched conditions falling below the average range of scores. The VISTECH test literature cautions that depressed contrast sensitivity scores may be due to normal varia-

tion and are not necessary indicative of visual problems. Further research may be warranted, however, to determine if there are operational environments which require the ability to read the kinds of stimuli such as those presented in lines C, D, and E of the VISTECH test. If there are such environments, then perhaps our data showing more below average scores for these lines for both the scratched and unscratched conditions and the lower scores with the scratched conditions in most cases will be of some importance. For now it remains unclear if these scores are a problem.

Study 2

A second study was done to look at a comparison of the VISTECH test of contrast sensitivity under two conditions, one of which was not present in the first study: Wearing the clear B-LPS and not wearing the B-LPS (this second condition was the one not in the first study).

Seven members of the Letterman Army Institute of Research who did not wear spectacles participated in the study. Only the VISTECH test of contrast sensitivity was administered to them under the two conditions of no B-LPS and clear B-LPS.

Table VII shows the scores of each subject under each of the two conditions for the Contrast Sensitivity Test, line A. All subjects scored in the normal range for this test under both conditions. Four of the subjects had higher scores for this test when they wore the clear B-LPS while the other three subjects had the same score for each condition.

Table VIII shows the scores of each subject under the two conditions for line B of the VISTECH test. All subjects were in the normal range under both conditions. Three subjects scored higher while wearing the clear B-LPS than they did with no B-LPS.

Table IX shows the scores of each subject under the two conditions for line C of the Contrast Sensitivity Test. Three subjects were in the below average range for the no B-LPS condition and four were in the below average range for the with B-LPS condition. Three subjects scored lower by one point in going from the no B-LPS to clear B-LPS condition. Two subjects scored

higher in the with B-LPS condition (one of the subjects was two points higher in this condition). Two subjects scored the same under each condition.

Table X shows the scores of each subject under the two conditions for line D. All scores except one in the no B-LPS condition fall in the below average range. The scores also remain constant under the two conditions, except for one subject who gains one point in going from the no B-LPS to clear B-LPS condition.

Table XI shows the scores of each subject under the two conditions for line E. Four scores in the no B-LPS condition are in the average range while only two scores in the clear B-LPS condition are in the average range. Three subjects have lower scores in the clear B-LPS condition as compared to the no B-LPS condition (one score goes from 4 to 0, another from 3 to 2, and another from 2 to 1). Two subjects have scores of zero under both conditons, and another subject has a score of 2 under both conditions.

Overall, while under some of the portions of the VISTECH contrast sensitivity test subjects have higher scores with clear B-LPS and under other portions subjects have lower scores, there appear to be no major problems in the wear of the B-LPS. This is essentially similar to the findings of Study 1. The VISTECH test also cautions that, in many cases, depressed contrast sensitivity is strictly due to normal variation and is not indicative of visual problems.

APP D

Table I

Snellen Eye Chart

Subject	Clear BLPS	Scratched Clear BLPS	Change
1	20/15	20/15	
2	20/15	20/15	
3	20/15	20/15	
4	20/15	20/15	
5	20/15	20/ :0	+

Subject	Clear Brown	Scratched Brown	Change
1	20/20	20/20	
2	20/15	20/20	-
3	20/15	20/15	
4	20/15	20/20	-
5	20/15	20/20	-

Subject	Laser/Clear	Scratched Laser/Clear	Change
1	20/15	20/15	
2	20/15	20/20	-
3	20/15	20/15	
4	20/15	20/15	
5	20/15	20/15	

APP D

Table II

Contrast Sensitivity, Line A

(Average Score Range is 5 to 7)

Subject	Clear BLPS	Scratched Clear BLPS	Change
1	7	6	-
2	6	6	
3	8	8	
4	7	6	-
5	7	6	-

Subject	Clear Brown	Scratched Brown	Change
1	6	8	+
2	5	5	
3	8	8	
4	7	5	-
5	6	7	+

Subject	Laser/Clear	Scratched Laser/Clear	Change
1	7	7	
2	5	5	
3	6	8	+
4	6	8	+
5	6	6	

Table III

Contrast Sensitivity, Line B

(Average Score Range is 5 to 7)

Subject	Clear BLPS	Scratched Clear BLPS	Change
1	8	8	
2	7	6	-
3	8	6	-
4	7	7	
5	8	7	-

Subject	Clear Brown	Scratched Brown	Change
1	7	8	+
2	6	5	-
3	8	8	
4	7	6	-
5	7	6	-

Subject	Laser/Clear	Scratched Laser/Clear	Change
1	7	8	+
2	7	5	-
3	8	6	-
4	7	6	-
5	7	7	

Table IV

Contrast Sensitivity, Line C

(Average Score Range is 5 to 7)

Subject	Clear BLPS	Scratched Clear BLPS	Change
1	7	6	-
2	4	4	
3	6	5	-
4	6	5	-
5	7	6	-

Subject	Clear Brown	Scratched Brown	Change
1	6	5	-
2	4	4	
3	5	3	-
4	4	4	
5	4	4	

Subject	Laser/Clear	Scratched Laser/Clear	Change
1	6	6	
2	4	4	
3	4	2	-
4	5	4	-
5	5	4	-

Table V

Contrast Sensitivity, Line D

(Average Range is 4 to 7)

Subject	Clear BLPS	Scratched Clear BLPS	Change
1	3	4	+
2	3	3	
3	3	3	
4	3	1	-
5	6	4	-

Subject	Clear Brown	Scratched Brown	Change
1	3	4	+
2	2	2	
3	2	2	
4	2	2	
5	3	2	-

Subject	Laser/Clear	Scratched Laser/Clear	Change
1	4	3	-
2	2	2	
3	3	3	
4	3	2	-
5	4	2	-

Table VI

Contrast Sensitivity, Line E

(Average Score Range is 2 to 6)

Subject	Clear BLPS	Scratched BLPS	Change
1	1	1	
2	0	0	
3	1	0	-
4	0	0	
5	3	3	

Subject	Clear Brown	Scratched Brown	Change
1	1	1	
2	0	0	
3	0	0	
4	0	0	
5	1	0	-

Subject	Laser/Clear	Scratched Laser/Clear	Change
1	1	1	
2	0	1	+
3	0	0	
4	1	0	-
5	2	0	-

Table VII

Contrast Sensitivity, Line A

(Average Score Range is 5 to 7)

Subject	No BLPS	Clear BLPS	Change
1	5	6	+
2	5	6	+
3	6	6	
4	5	6	+
5	6	6	
6	5	5	
7	6	7	+

Table VIII

Contrast Sensitivity, Line B

(Average Score Range is 5 to 7)

Subject	No BLPS	Clear BLPS	Change
1	6	7	+
2	6	7	+
3	7	7	
4	6	6	
5	6	6	
6	6	7	+
7	7	7	

Table IX

Contrast Sensitivity, Line C

(Average Score Range is 5 to 7)

Subject	No BLPS	Clear BLPS	Change
1	5	4	-
2	5	4	-
3	4	6	+
4	3	3	
5	5	4	-
6	5	5	
7	6	7	+

Table X

Contrast Sensitivity, Line D

(Average Score Range is 4 to 7)

Subject	No BLPS	Clear BLPS	Change
1	3	3	
2	2	2	
3	3	3	
4	2	2	
5	3	3	
6	3	3	
7	3	4	+

Table XI

Contrast Sensitivity, Line E

(Average Score Range is 2-6)

Subject	No BLPS	Clear BLPS	Change
1	2	1	-
2	4	0	-
3	0	0	
4	0	0	
5	2	2	
6	1	1	
7	3	2	-

APPENDIX E

NOTE: The following analysis was performed by Dr. James Sheehy of the Vision Laboratory, Naval Air Development Center, Warminster, PA as a courtesy to the authors. This appendix was written by Dr. Sheehy. We wish to thank Dr. Sheehy for his timely assistance in completing these tests.

All haze measurements were performed using a Gardner model XL 211 Hazeguard system. Haze is defined as the percentage of light which deviates from the incident beam by forward scattering when passing through a sample. Light flux deviating by more than 2.5 degrees from the incident beam is considered to be haze (ASTM D 1003). Haze is caused by small particles, scratches, and impurities in a sample which cause light to be refracted or reflected. After passing through the sample the light enters an integrating sphere monitored by a high sensitivity photodetector. If haze is not present in the sample the light will pass through and exit the sphere without scattering.

All samples were placed at the entrance port of the sensing unit. The .75 inch diameter of the incident light beam defines the maximum area that haze is assessed over during a single measurement. Each lens was placed in the measuring beam so that a point 32 mm (based on an average IPD of 64 mm) from the center of the nose piece was in the center of the beam. This insured that the percentage of haze reported was not inflated by assessing areas where scratching and abrasion were maximal (typically by the nose piece or the temporal edge of the lens where the fasteners are located.) Haze measurements are listed in Table 1.

The values listed in Table 1 represent the percent of haze a user with an IPD of 64 mm would see when looking directly ahead. The estimate will vary if their gaze deviates to a portion of the lens where haze is maximal. For example, the clear eyewear labeled #57 has 5.3% and 8.3% haze for the right and left lens respectively. It the user deviates his gaze upward haze at that point is 25.5% and 37.5% for the right and left lens. These values are in contrast to those measured for #63, which is a new clear lens, representing a significant increase in haze in the scratched #57.

APP E

TABLE 1

Sample	Percent Haze	
	Right Lens	Left Lens
FT 01	7.08	12.02
FT 03	3.60	2.97
FT 04	1.07	.88
FT 05	2.22	4.40
SNG 01	1.40	1.50
SNG 02	3.70	3.70
SNG 03	7.70	19.90
SNG 58	13.40	7.70
CLR 31	2.00	1.50
CLR 69	2.60	2.70
CLR 57	5.30	8.30
CLR 58A	8.00	6.60
CLR 58B	5.70	2.70
CLR 63	.20	.10
CLR 44	1.40	1.20

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