TECHNICAL REPORT
NATICK/TR-00/007

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COMBINATION ANTIFOG/ANTISCRATCH COATING APPLIED TO SPECIAL PROTECTIVE EYEWEAR, CYLINDRICAL SYSTEM (SPECS): EXPERIMENTAL TRIALS

Michelle Markey and Harold Moody

November 1999

Final Report

January 1998 – June 1999

Approved for public release, distribution unlimited

U.S. Army Soldier and Biological Chemical Command
Soldier Systems Center
Natick Massachusetts 01760-5000

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
15 Nov 1999	Final	Jan 1998 - Jun 1999

4. TITLE AND SUBTITLE

COMBINATION ANTIFOG/ANTISCRATCH COATING APPLIED TO SPECIAL PROTECTIVE EYEWEAR, CYLINDRICAL SYSTEM (SPECS): EXPERIMENTAL TRIALS

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
PR643747

6. AUTHOR(S)
Michelle Markey and Harold Moody

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Soldier and Biological Chemical Command
Product Manager--Enhanced Soldier Systems
ATTN: AMSSB-PM-RST-E(B)
Natick, MA 01760-5019

8. PERFORMING ORGANIZATION REPORT NUMBER
NATICK/TR-00/007

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Soldier and Biological Chemical Command
Product Manager--Land Warrior
10401 Totten Road, Suite 121
Fort Belvoir, VA 22060

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The potential for eye injuries on the battlefield has increased over the years due to advances in fragmenting munitions and the increased use of lasers on the battlefield. Though the eye is extremely susceptible to damage, even by small, low-velocity projectiles, the eye can easily be protected with proper eyewear. Current military protective eyewear systems, however, are prone to fogging. Antifog coatings exist, though have traditionally been incompatible with antiscratch coatings required to protect the polycarbonate base from which most military eyewear is made. Manufacturers have made recent efforts to develop a coating that offers both antiscratch as well as antifog protection. The report documents one effort in which such a coating is applied to a military item. The experimental antifog/antiscratch samples evaluated in this particular study do note demonstrate durable antifog capabilities. Scratch resistance and resistance to insect repellent (DEET) were inferior as compared to standard samples. Since only one combination antifog/antiscratch coating was investigated for this particular study, additional combination antifog/ antiscratch coatings warrant further investigation as they become available.

15. SUBJECT TERMS

EYE PROTECTION	SCRATCH RESISTANT PLASTICS	CHEMICAL RESISTANCE
PROTECTIVE EYEWEAR	ANTIFOGGING AGENTS	COATINGS
SCRATCH RESISTANCE	BALLISTIC RESISTANCE	ABRASION

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Harold Moody
U	U	U	U	27	19b. TELEPHONE NUMBER *(Include area code)* (508) 233-5580

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PREFACE

The potential for eye injuries on the battlefield has increased over the years due to advances in fragmenting munitions and the increased use of lasers on the battlefield. Though the eye is extremely susceptible to damage, even by small, low-velocity projectiles, the eye can easily be protected with proper eyewear. Current military protective eyewear systems, however, are prone to fogging. Antifog coatings exist, though have traditionally been incompatible with the antiscratch coatings required to protect the polycarbonate base from which most military eyewear is made. Manufacturers have made recent efforts to develop a coating offering both antiscratch as well as antifog protection. The following report documents one effort in which the government researchers evaluated such a coating procured from one of these manufacturers on a military item.

ACKNOWLEDGMENTS

Mr. Barry DeCristofano and Mr. Gregg Kreinsen are recognized for their expertise and time spent in measuring various performance characteristics of both standard and experimental eyewear in support of this effort. Mr. Charles Greene is recognized for coordinating and reporting on evaluation of both standard and experimental eyewear in the field.

Combination Antifog/Antiscratch Coating Applied to Special Protective Eyewear, Cylindrical System (SPECS): Experimental Trials

1. Purpose:

The project's purpose is to determine the feasibility of applying new, commercially available antifog/antiscratch coatings to military protective eyewear, and to determine whether the new coatings have any detrimental effects on other eyewear performance characteristics.

2. Background:

The Special Protective Eyewear, Cylindrical System (SPECS) (Performance Specification MIL-PRF-31013)[1] and other eyewear systems currently in production are being manufactured from a polycarbonate substrate. Polycarbonate is an inherently soft material that scratches easily and must be treated with a hardcoat to promote scratch resistance. In the past, such hardcoats were not compatible with antifog treatments. Soldiers in the field have stated that fogging is a problem with such eyewear. New combination antifog/antiscratch coatings are now commercially available.

3. Materials:

Experimental eyewear of the following types were obtained from Mine Safety Appliances (MSA), Pittsburgh, PA. Each item had been treated (both front and back surfaces of each lens) with an antifog/antiscratch coating (between 4 and 5 μm in thickness). The source of the coating is unknown.

SPECS Class 1: Clear, ballistic SPECS treated with antifog/antiscratch coating (40 large, 40 regular)
SPECS Class 3: Laser protective, two-wavelength, ballistic SPECS treated with antifog/antiscratch coating (20 regular)

Standard samples (i.e., samples that conform to MIL-PRF-31013) were also tested along with the experimental eyewear for comparison purposes for certain performance characteristics. Standard samples from two manufacturers (MSA and Uvex) were used:

SPECS Class 1: Standard clear, ballistic SPECS, untreated (i.e., no antifog coating; sample treated with standard hard-coat for antiscratch only).

Standard samples were selected from lots that had successfully completed the testing required in MIL-PRF-31013, and were not subjected to parallel testing with the experimental eyewear if testing duplicated that required in MIL-PRF-31013.

4. Performance Requirements/Verification Methods:

a. The experimental eyewear was tested in a laboratory environment for performance characteristics that could be affected by the application of a coating, and quality of the coating applied. The eyewear was not tested for performance characteristics related to configuration or to quality of the optical molding process. The following performance characteristics were evaluated:

Ballistic resistance
Chemical resistance
Temperature
Solar radiation
Flammability
Abrasion resistance
Adhesion
Fogging

b. The experimental eyewear and standard eyewear were both tested for performance by soldiers in the field.

5. Results:

a. Laboratory Evaluation

1) Ballistic Resistance

Requirement: Per MIL-PRF-31013, the ballistic resistance of the spectacles shall be such that they will pass a V_0 test using a 0.15 caliber, 5.8 grain, T37 shaped projectile at a velocity of 640 to 660 feet per second.

Verification: Verification was conducted in accordance with MIL-PRF-31013, which states "The test shall be a V_0 test conducted as specified in MIL-STD-662[2] using a 0.15 caliber, 5.8 grain, T37 shaped projectile ... with the following exceptions: electronic velocity detection devices (light beam or acoustic type) may be used to determine the velocity of the projectile, such devices placed no less than 8 inches and no more than 24 inches from the target; compressed gas propulsion of the projectile may be used. The eyewear shall be mounted on an Alderson 50th percentile male headform in the as-worn position. The 0.002 inch thick aluminum foil witness sheet shall be mounted within 2 inches of the eyewear behind the area of impact. The sample shall be hit once at normal incidence within a 1-inch diameter circle at a point centered vertically and at a horizontal distance of 32 mm from the centerline. The sample shall be considered a failure if the aluminum foil witness sheet is punctured or if the sample is cracked."

The T37 shaped projectile was fired through a compressed gas gun. An electronic light sensor was used to determine the velocity, which ranged from 640-660 ft./s. Three experimental samples were tested.

Test/Results: Each of the three samples tested met the specification requirements.

Table 1. Ballistic Test Results

SAMPLE	PROJECTILE VELOCITY	BALLISTIC RESULTS (PASS/FAIL)
Sample A: SPECS Class 1, size large (left eye)	648 ft/s.	Pass
Sample B: SPECS Class 1, size regular (right eye)	651 ft/s.	Pass
Sample C: SPECS Class 3, size regular (left eye)	645 ft/s.	Pass

2) Chemical Resistance

Requirement: Per MIL-PRF-31013, the SPECS components shall be resistant to attack from chemicals including, but not limited to, the following: Insect repellent, controlled release (DEET), Combat vehicle fluid (Dexron), gasoline, motor oil, JP8 aircraft fuel.

Verification: Verification was conducted in accordance with MIL-PRF-31013, which states "The surface shall be exposed to the specified chemicals for a 24-hour period. The chemical may be contained by sealing an O-ring to the surface using silicone grease. The O-ring shall be filled with the chemical and left for a 24-hour period. At the end of the test period the surface shall be cleaned and inspected for visible damage and optical distortion."

Two separate experimental eyewear samples were tested for each chemical at ambient room temperature and humidity. Chemicals were tested on the left side of the first sample, and on the right side of the second, and were tested on the inside of the lens. O-rings sealed with silicon caulking were used to contain the chemicals (as leakage was observed in previous tests when silicon grease was used). The fluids contained by the O-rings, particularly JP8 and gasoline, were replenished periodically over the 24 hour period due to evaporation. Lastly, Dexron was unavailable for the test, thus Transmission Fluid, Type F (M2C33-F) was used as a substitute.

Test/Results:
The samples were visually inspected after chemical exposure. With the exception of those exposed to DEET, all samples were unaffected. The samples exposed to DEET appeared hazy. The coating on the surface of these samples looked as if it had been dissolved where it came into contact with the DEET.

Table 2. Chemical Test Results

SAMPLE	CHEMICAL	CHEMICAL RESULTS (PASS/FAIL)
Sample D: SPECS Class 1, size regular (left eye)	Transmission fluid, Type F (M2C33-F) (in place of Dextron)	Pass
Sample D: SPECS Class 1, size regular (right eye)	DEET insect repellent	Fail (area exposed to chemical appears hazy; coating on the surface of these samples looked as if it had been dissolved where it came into contact with the DEET)
Sample E: SPECS Class 1, size regular (left eye)	DEET insect repellent	Fail (area exposed to chemical appears hazy; coatings on the surface of these samples looked as if it had been dissolved where it came into contact with the DEET)
Sample E: SPECS Class 1, size regular (right eye)	Motor Oil	Pass
Sample F: SPECS Class 1, size regular (left eye)	Motor Oil	Pass
Sample F: SPECS Class 1, size regular (right eye)	Gasoline	Pass
Sample G: SPECS Class 1, size regular (left eye)	Gasoline	Pass
Sample G: SPECS Class 1, size regular (right eye)	JP8	Pass
Sample H: SPECS Class 1, size regular (left eye)	JP8	Pass
Sample H: SPECS Class 1, size regular (right eye)	Transmission fluid, Type F (M2C33-F) (in place of Dexron)	Pass

3) Temperature

Requirement: Per MIL-PRF-31013, the SPECS lens shall not be visibly degraded following exposure for 72 hours at 160°F and 72 hours at -60°F ± 3°F.

Verification: Verification was conducted in accordance with MIL-PRF-31013, which states "The sample shall be exposed for 72 hours at 160°F and 72 hours at -60°F, held to within ±3°F throughout the entire period."

Two experimental samples were tested.

Test/Results:
The samples were visually inspected after temperature exposure. No visual degradation was observed.

Table 3. Temperature Exposure Test Results

SAMPLE	TEMPERATURE * RESULTS (PASS/FAIL)
Sample I: SPECS Class 1, size regular	Pass
Sample J: SPECS Class 3, size regular	Pass

*72 h at 160°F, 72h at -60°F±3°F

4) Solar Radiation

Requirement: Per MIL-PRF-31013, the SPECS lens shall not be visibly degraded when tested against 60 hours of simulated solar radiation.

Verification: Verification was conducted in accordance with MIL-PRF-31013, which states "The samples shall be placed in a solar simulator using a xenon arc lamp filtered with two borosilicate glass filters to simulate the spectral energy distribution of direct sunlight. The sample shall be placed at a suitable distance from the source and the source intensity adjusted so that the total integrated irradiance at the surface of the sample is 1120 watts/m^2. The total exposure shall be three cycles. In each cycle the sample shall be exposed for 20 hours to the full intensity followed by a period of no exposure for 4 hours. The total exposure shall be 60 hours."

Two experimental samples were tested.

Test/Results:
The samples were visually inspected after exposure to simulated solar radiation. No visual degradation was observed.

Table 4. Solar Radiation Test Results

SAMPLE	SOLAR RADIATION RESULTS (PASS/FAIL)
Sample K: SPECS Class 1, size regular	Pass
Sample L: SPECS Class 1, size regular	Pass

5) Flammability

Requirement: Per MIL-PRF-31013, the eyewear must be compliant with ANSI-Z87.1 – 1989, Practice for Occupational and Educational Eye and Face Protection[3]. Flammability was identified as a performance characteristic that could be affected by the application of an antifog/antiscratch coating. It was judged that other ANSI Z87.1 characteristics would not be affected by the application of such a coating. Per ANSI Z87.1, the flammability requirement is as follows: "The spectacles shall not continue to burn after exposure to a 50 mm (2 in) flame from a 10 mm (0.393 in) Bunsen burner for one and on-half seconds."

Three experimental samples were tested.

Verification: Verification was conducted in accordance with ANSI Z87.1, which specifies the following test apparatus: "The protective device is held with a clamp in the approximate orientation in space it would have if worn by a standing user. The flame source shall be a 10 mm (0.393 in) Bunsen burner with a 50 mm (2 in) blue flame having an inner cone of 25 mm (1 in). The test shall be conducted in a draft-free environment." The verification states the following procedure:

"(1) Apply the flame to a point (test point) on the device for one second.

(2) Remove the flame from the test point.

(3) After five seconds, see if the test point is burning. If the test point has a visible flame, it is said to have ignited and it is assigned an "ignition time" of one second.

(4) If the test point did not ignite in one second, wait for ten seconds then reapply the flame for two seconds, wait ten seconds then reapply for three seconds, etc., repeating the above steps until the test point ignites or has not ignited after a five second application of the flame. Several test points shall be tested on each device until the point with the lowest average ignition time is determined. This test point then becomes the "chosen test point," and testing is carried out for a total of three specimens at this point."

Test/Results:
Each of the three samples met the one and one-half seconds requirement, failing to ignite even after a 5 second exposure. The surface of each lens did show indication of being exposed to a flame, having a "crackled" appearance in the area exposed.

Table 5. Flammability Test Results

SAMPLE	EXPOSURE TIME	FLAMMABILITY RESULTS (PASS/FAIL)
Sample A: SPECS Class 1, size large (right eye)	5 seconds	Pass
Sample B: SPECS Class 1, size regular (left eye)	5 seconds	Pass
Sample C: SPECS Class 3, size regular (right eye)	5 seconds	Pass

6) Abrasion Resistance

Requirement: Per MIL-PRF-31013, the percent haze gain of the SPECS lens shall not exceed 6 percent" when tested as specified.

Verification: The verification method described in MIL-PRF-31013 involves the use of flat plates coated at the same time as the eyewear itself. Flat samples were not available for the purpose of this investigation. The eyewear itself was, therefore, tested using an abrasion test method suitable for curved surfaces. The method, adapted from MIL-PRF-29580, Draft C[4], is as follows:

"Abrasion resistance. The haze and luminous transmittance of the coated lenses shall be determined before and after the abrasion test. The abrasion test shall be performed by rubbing with a specially standardized eraser, mounted as illustrated in Figure 1, and held approximately normal to the lens. The eraser shall be rubbed across the surface of the

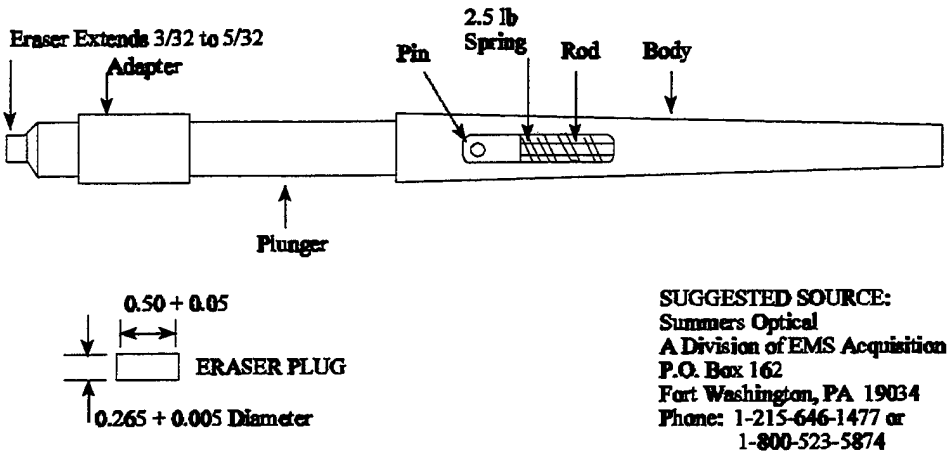

Figure 1. Eraser Abrasion Tester Assembly and Eraser Plug
(Dimensions in inches)

coated lens from one point to another, over the same path, for 20 completed cycles with a force of 2.0 to 2.5 pounds continuously applied. Wherever possible, rubs of about 1 inch length are preferred. After the rubbing has been completed, the lens shall be thoroughly cleaned to remove dirt, film, fingermarks and grease marks using a mild detergent and distilled water followed by drying with a soft cloth or lens tissue. The percent haze gain is the difference between the haze readings taken before and after the abrasion test. The

haze of the abraded track shall be measured in accordance with ANSI Z87.1." As allowed by MIL-PRF-29580, Draft C, an aperture was used to reduce the optical beam in the measurement apparatus to a size comparable to that of the abraded area.

Two standard samples and two experimental samples were tested.

Test/Results:

Table 6. Abrasion Test Results

SAMPLE	INITIAL HAZE	HAZE AFTER ABRASION	% HAZE GAIN	ABRASION RESULTS (PASS/FAIL)
Sample M: SPECS Standard sample (without antifog coating) CENTER OF RIGHT SIDE OF LENS	0.2%	2.9%	2.7%	Pass
Sample N: SPECS Standard sample (without antifog coating) CENTER OF LEFT SIDE OF LENS	0.2%	2.0%	1.8%	Pass
Sample O: SPECS Class 1, size regular (with antifog coating) CENTER OF RIGHT SIDE OF LENS	0.2%	6.2%	6.0%	Pass (Borderline)
Sample P: SPECS Class 1, size regular (with antifog coating) CENTER OF LEFT SIDE OF LENS	0.3%	7.6%	7.3%	Fail

7) Adhesion

Requirement: MIL-PRF-31013 does not include an adhesion paragraph. The following requirement, adapted from MIL-PRF-29580, Draft C and applicable to coated eyewear, was used by the experimenters:

If a coating has been applied to the lens, the coating shall not be removed, dislodged, or affected in any way. Removal or loosening of the coating shall be cause for rejection.

Verification: MIL-PRF-31013 does not include an adhesion paragraph. The following method, adapted from MIL-PRF-29580, Draft C, was used by the experimenters:

A cross-hatch pattern shall be cut into the front surface of the lens by making six parallel cuts in one direction and another six parallel cuts perpendicular to, and centered on, the first set of six. Cuts shall be approximately 2 millimeters apart and at least ¾ inches long. A test tape, with an adhesion rating of 40 ounces per inch of width, shall be firmly applied to the cross-hatch pattern on the front surface of the lens. The tape shall be removed using a snapping motion applied 90 degrees to the surface.

Two standard samples and two experimental samples were tested.

Test/Results:

Table 7. Adhesion Test Results

SAMPLE	ADHESION RESULTS (PASS/FAIL)
Sample M: SPECS Class 1, size regular (**without** antifog coating) LEFT SIDE OF LENS	Pass
Sample N: SPECS Class 1, size regular (**without** antifog coating) RIGHT SIDE OF LENS	Pass
Sample O: SPECS Class 1, size regular (**with** antifog coating) LEFT SIDE OF LENS	Pass
Sample P: SPECS Class 1, size regular (**with** antifog coating) RIGHT SIDE OF LENS	Pass

8) Fogging

Requirement: MIL-PRF-31013 does not have a requirement for fogging resistance, and a standardized requirement could not be identified. The following requirement was therefore used by the experimenters:

The eyewear shall maximize resistance to fogging so as to minimize interference with vision. Complete resistance to fogging is desired.

Verification: No standard government or commercial test method could be identified. The following test method was created by the experimenters for the purpose of this evaluation:

A container shall be filled with boiling water. The lens sample shall be immediately placed over the container in the escaping steam such that the lens is positioned parallel to the direction of flow of the escaping steam. The lens shall by visually examined for fogging. A minimum of four trials shall be conducted. In-between each trial, the sample shall be wiped dry with a dry tissue.

Two standard samples and two experimental samples were tested.

Test/Results:

Table 8. Fogging Test Results

SAMPLE	FOGGING RESULTS
Sample Q: SPECS Class 1, size large (**with** antifog coating)	First trial: No fogging; sample merely became wet from the steam Second trial: Small areas of "flash fogging" were evident, which quickly disappeared Third trial: Some areas of "flash fogging" evident, which quickly disappeared Fourth trial: Larger areas of constant fog were evident
Sample R: SPECS Class 1, size large (**with** antifog coating)	First trial: No fogging; sample merely became wet from the steam Second trial: Small areas of "flash fogging" which quickly disappeared Third trial: Larger areas of constant fog were evident Fourth trial: Even larger areas of constant fog were evident
Sample S: SPECS Standard sample from Uvex (**without** antifog coating)	Sample fogged immediately; fog remained until sample was removed from the steam, at which point the fog slowly dissipated; subsequent trials yielded the same results
Sample T: SPECS Standard sample from MSA (**without** antifog coating)	Sample fogged immediately; fog remained until sample was removed from the steam, at which point the fog slowly dissipated; subsequent trials yielded the same results

b. Field Test Evaluation

Test: Sixty SPECS were sent to Fort Drum, NY, for a field test in the following configurations: 10 size large antifog SPECS (designated AL), 20 size regular antifog SPECS (AR), 10 size large standard (baseline) SPECS (BL), and 20 size regular standard

SPECS (BR). Forty-eight SPECS were returned as follows: 5 AL, 16 AR, 9 BL, and 18 BR.

SPECS returned from the Field Test were numbered as received and sorted as follows:

Heavy use: dirty (especially around the nosepieces and temples), greasy, worn or missing parts
Moderate use: some dirt, many fingerprints, slightly worn temple pieces, slightly dirty headband (if available)
Limited use: packaging removed, a few fingerprints
No use: packaged as shipped

Results:

Table 9. Visual Assessment of Field Tested Eyewear

CONDITION	VISUAL ASSESSMENT	
	Antifog SPECS	Standard SPECS
Heavy Use	2 (no.1AL, no.14 AR) Many scratches, no effective antifog coating remains	2 (no.2 BL, no.16 BR) Few scratches on no.2, many scratches on no.16
Moderate Use	5 (no. 2,4AL, no.1,4,15 AR) Scratched, gritty, some loss of antifog performance, one broken temple	4 (no.1BL, no.4,9,10 BR) Few to no scratches
Limited Use	10 (no.5AL, no.2,3,6,9,10, 11,12,13,16AR) No scratches, in most cases antifog coating is ok; on two lenses there is some loss of antifog performance	11 (no.4,5,8,9BL, no.1,2, 3,11,12,14,15BR) In most cases, no scratches; one lens has minor scratches; one lens has moderate scratches
No use	4 (no.3AL,no.5,7,8 AR)	8 (no.3,6,7BL,no.5-8,13 BR)
Not returned	9 5 AL, 4 AR	3 1 BL, 2 BR

The condition of the hardware appears to reflect the results of the User Survey (see Appendix A). Thirty four items indicate some amount of use, with some apparently only removed from the packaging and returned to the case, compared to 22 soldiers participating in the survey. From the inspection, it was apparent that 13 items received moderate to heavy use; this compares to 11 claims of durability issues with scratches and

chemical degradation in the survey. Most of the antifog items that received moderate to heavy use no longer demonstrated antifog capability; the survey indicates that there was no significant difference in performance between the antifog eyewear and the standard eyewear. (For these samples, the antifog assessment is based on attempts to fog the lenses by breathing on them.)

The broken temple piece on item 4 AR can be attributed to the manufacturer's improper assembly on the temple/browbar, which led to additional force being required for adjustment, causing the break.

6. Discussion:

The laboratory test results indicate that the SPECS treated with the experimental antifog/antiscratch coating are inferior to the standard SPECS for the following characteristics: Chemical Resistance (exposure to DEET) and Abrasion Resistance. Standard SPECS are known to pass the chemical resistance test for exposure to DEET. Regarding abrasion resistance, the experimental samples revealed higher increases in haze than standard samples after abrasion. Of the two experimental samples tested for abrasion resistance, one demonstrated a high enough haze gain to result in a failure for that test. The other sample passed, though was borderline. Lastly, it was noted during laboratory fogging trials that the experimental samples initially did well; however, the antifog characteristics deteriorated with each subsequent trial, rendering the antifog characteristics essentially ineffective after only a brief period. This finding agrees with the results of the field trials of the experimental eyewear.

Regarding field testing, the limited amount of information available due to the low usage rate does not allow for a statistical analysis. However, some trends can be observed. Examination after use indicates that the antifog coating may not be very durable, and under the same use and care conditions as the standard item, the coating may be worn off. Once the coating is worn off, it has the same antifog capabilities as a standard coated item. It is, however, more susceptible to scratching. It would appear that in an environment where frequent cleaning is necessary, there is no advantage to using the antifog coating supplied for this evaluation.

7. Conclusions:

The experimental antifog/antiscratch samples evaluated in this study do not demonstrate a durable antifog capability. Scratch resistance and resistance to DEET were inferior as compared to standard samples. Some tradeoffs may be acceptable by the user community if durable antifog characteristics can be achieved. Since only one combination antifog/antiscratch coating was investigated for this particular study, additional combination antifog/antiscratch coatings warrant further investigation as they become available.

References:

1. MIL-PRF-31013 (25 April 1996), Spectacles, Special Protective Eyewear Cylindrical System (SPECS)

2. MIL-STD-662E (27 May 92), V50 Ballistic Test for Armor

3. ANSI-Z87.1 – 1989, Practice for Occupational and Educational Eye and Face Protection

4. MIL-PRF-29580C (draft, dated 10 February 1998), Spectacles, Aviator's, Multiple Wavelength Laser Protective, EDU-5/P (with Case) (similar abrasion and adhesion testing conducted)

5. ASTM D 1003 – 95, Standard Test Method For Haze and Luminous Transmittance of Transparent Plastics

6. ASTM G 26 – 93, Standard Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials

7. ASTM D 3359 – 95a, Standard Test Methods for Measuring Adhesion by Tape Test

Appendix

SUMMARY – SPECS ANTI-FOG COATING EVALUATION

By Charles Greene
U.S. Army Soldier and Biological Chemical Command

Appendix.

SUMMARY – SPECS ANTIFOG COATING EVALUATION

Test Design

The goal of this test was to determine if an antifog coating on the clear SPECS lens would have any noticeable impact on the users' perception of the frequency and severity of fogging. Approximately 50 soldiers from the U.S. Army's 10th Mountain Division were issued test items prior to their departure for a three-week training exercise at Fort Polk, LA (Joint Readiness Training Center). Half of the group received a pair of SPECS with the antifog coating and half received a standard pair (no coating). This was a blind study – participants did not know which set they had received. At the end of the test, the soldiers completed a questionnaire designed to assess the impact of the antifog coated SPECS.

Survey Sample

The survey group consisted of 22 male soldiers from the 10th Mountain Division who used either the standard (n=14) or modified SPECS (n=8) during a training rotation to JRTC, Fort Polk, LA. The average length of Army service for these troops was three years (36 months) and the average age was 23. All were Infantrymen holding enlisted rank (86% E-2 to E-4, 14%; E-5 to E-7). None of the respondents indicated that they wore corrective lenses and only about one-fourth (23%, n=5) reported that they normally wore eye protection either in the field or in garrison.

Amount of Use

While there was an obvious difference between the amount of time the standard SPECS were reportedly worn (X=77 hours) and the amount of time the modified were worn (X=19 hours), a t-test determined that this was not a significant difference. The test items were issued randomly and troops were not told if they received a standard item or one with the antifog coating. We assume that the difference in wear time is merely due to chance rather than some issue with the antifog coating. However, this difference may have an impact on the data related to perceptions of lens fogging.

Most of the troops reported that they wore the SPECS during the day (n=20) as opposed to night (n=7). The items were worn for patrols (n=12), on the Military Operation in Urban Terrain (MOUT) course (n=4), IMT (n=3), helicopter operations (n=3), and preparing fighting positions (n=2).

Most of the troops felt that the SPECS they were issued fit them (n=18). Those who did not reported that they were too big (n=2) or were too tight at the nose (n=1) or ear (n=1). It should also be noted that none of the troops reported adding any kind of commercial antifog treatments to the items they were issued.

SPECS Durability

Note: There were no significant differences for durability between the standard and antifog SPECS.

About one third of the troops (36%, n=8) experienced some type of durability problem with the SPECS. Specific problems were scratches on the lenses (n=4) or broken arms (n=2). Generally, these problems developed in the first one to three days of use. Two soldiers also reported that the lenses were scratched to the point where they had to stop wearing the SPECS.

Many of the respondents reported that the SPECS lenses were exposed to both camouflage face paint (n=18) and insect repellent (n=10). Overall, this exposure had either no effect (n=11), or only a minor effect (n=4), on the clarity of the lens. Three respondents did report that these materials had a major effect on the lens, permanently clouding it.

Compatibility

Note: There were no significant differences for compatibility between the standard and antifog SPECS.

The troops did report some compatibility problems with the Personnel Armor Systems Ground Troop (PASGT) Helmet (n=7), the M-16A2 (n=3), and the M-249 SAW (n=2). In general, the problem with the helmet was that the brim tended to hit the top of the SPECS. Weapons problems were related to lens clarity (n=2).

Fogging

Note: While there were no significant differences for fogging, the data have been split between the standard and antifog groups.

Overall, 57% (n=8) of the troops with the antifog coating reported that they had a problem with fogging while only 38% of those with the standard item reported the same type of problem.

Thes data are curious. The troops with the antifog coating, who wore only the SPECS for a total of 17 hours, reported more problems with fogging than those who had untreated lenses and wore them for 77 hours. It could be a function of the low number of respondents. Small data sets are statistically less reliable than larger ones. The smaller the data set, the harder it is to find a significant difference and the difference between the two groups for fogging problems was not statistically significant.

For both groups, when fogging occurred, it was generally on the inside of the lens (n=8), with some respondents noting that fogging occurred on both the inside and outside of the lens (n=3). Overall, the troops reported that they had to wipe the SPECS lens clean about every 10 minutes during periods of fogging.

Safety

Half of the troops (50%, n=11) felt that the SPECS had prevented an eye injury. These respondents noted that the item had protected their eyes from branches and brush (n=5) or from flying debris (n=3) encountered while rappelling, firing their weapon, or when working around helicopters.

Comfort

Slightly more than half of the troops (55%, n=12) felt that the SPECS were comfortable to wear. Those who did not think they were comfortable reported the following problems: that the helmet brim pushed down on the top of the frame and caused discomfort (n=3), the arms were tight at the temples (n=1), and general ear discomfort (n=1).

Overall Ratings

The respondents rated the performance of the SPECS they were issued on a variety of criteria. Since there was no significant difference based on SPECS type, the data have been combined for both the antifog and standard groups. The scale used and results obtained are presented below.

VERY DISSATISFIED	MODERATELY DISSATISFIED	SOMEWHAT DISSATISFIED	NEITHER DISSATISFIED NOR SATISFIED	SOMEWHAT SATISFIED	MODERATELY SATISFIED	VERY SATISFIED
1	2	3	4	5	6	7

Criteria	$\bar{X}$
Amount of area covered	5.6
Level of protection	5.9
Resistance to scratching	4.4
Resistance to fogging	4.3
Clarity/ability to see	5.0
Durability	4.8
Compatibility with the helmet	4.6
Compatibility with weapons	4.9
Comfort	4.8
Overall performance	4.9

As can be seen above, the areas that caused problems for many of the troops (comfort, resistance to scratching, and resistance to fogging) tended to be the lowest rated criteria. It is also interesting to note that the mean for "resistance to fogging" was nearly identical for troops in the two groups (4.3 for standard, 4.4 for antifog). Level of protection was the highest rated criteria, which is not surprising since more than half of the respondents felt that the SPECS had prevented an eye injury.

Discussion

It would seem that the use of the antifog coating on the SPECS did not have an appreciable impact on the soldier's perception of either the frequency or extent of fogging for this survey group. There were some problems with the data: the findings may be affected by the relatively low number of questionnaires completed and the low amount of wear for the antifog group. However, the data obtained during this evaluation would suggest that the troops did not notice the impact of the antifog coating in the conditions and training environment in which they used the SPECS.

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