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COLD WEATHER GOGGLES:

III. Resistance to Fogging

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Naval Medical Research & Development Command
Research Work Unit M0095-PN.001-1040

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SUMMARY PAGE

THE PROBLEM

To assess the tendency to fog of various goggles designed to protect the eyes from the cold.

FINDINGS

There were large differences in the visibility of the low contrast target through the various goggles, although these differences declined as the target contrast increased. Those goggles advertised to be resistant to fogging performed well.

APPLICATION

Resistance to fogging must be one of the characteristics taken into consideration when specifying the optimal characteristics for goggles to be supplied to Marines operating in the cold. These results will be useful in setting optimal specifications for military goggles.

ADMINISTRATION INFORMATION

This research was conducted as part of Naval Medical Research and Development Command Research Work Unit M0095-Pn.001-1040 - Protective devices for the eye in cold weather. It was submitted for review on 13 April 1982, approved for publication on 17 May 1982, and designated as NSMRL Rep. No. 982.

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ABSTRACT

Twelve pairs of goggles designed to protect the eyes from conditions in the cold were tested for their tendency to fog while being worn during strenuous exercise in very low temperatures. Subjects reported the visibility of targets of various contrasts during 15-minute periods of exercise. The times at which the different targets became invisible were recorded. There were wide differences between the goggles in their resistance to fogging as revealed by the ability of the subjects to detect the lowest contrast target; these differences declined as target contrast increased. In general, goggles advertised by the manufacturers to be resistant to fogging performed well and were better than goggles by the same manufacturer not so advertised.

In a previous study, a sample of commercially available goggles designed to protect the eyes from the cold was evaluated for optical characteristics.[1] Special consideration was given to the extent of protection afforded by the goggles from the hazards presented by various types of radiant energy. In a second report,[2] the effects of wearing these goggles were assessed on a group of subjects who performed tasks that Marines would ordinarily carry out in the field. In both reports it was noted that the resistance to fogging of cold weather goggles is very important to the wearer. A pair of fogged goggles renders the wearer virtually blind, forcing him to remove them and lose the protection they provide.

A preliminary study of the resistance to fogging of the various goggles was described in the first report. Somewhat artificial conditions were employed, however. The procedure, briefly, was as follows: The goggles were first chilled to 0°F. Six subjects then donned them immediately in an ambient temperature of either 40, 50, or 60° F. The cold goggles fogged immediately in the warmer air. The amount of time taken for three low contrast (.05, .08, and .15) targets to become visible through the goggles, as they cleared, constituted the indirect measure of fogging resistance. It was assumed that the time required for a goggle to clear is related to the time needed for it to become fogged. Presumably, a goggle that takes a long time to clear does so because it is heavily fogged. This in turn is due to a lower resistance to fogging. An enormous range of clearing times was found in that experiment with reasonably stable results for a given goggle.

Recently an opportunity arose to test the resistance of the goggles to fogging directly, under conditions which closely resembled natural ones, and with a larger number of subjects. This report gives the results of this experiment.

METHOD

Goggles - Twelve goggles were tested. Eleven are commercially available; the twelfth is the Marine Corps issue. The goggles are identified as either single- (1) or double- (2) pane filters; advertised by the manufacturer as having been treated to resist fogging (F) or not; and by the percent of visible transmittance through the filter. One of the goggles had glass filters rather than plastic ones; it is identified as G-12, a single pane filter which transmits 12 percent of the visible light.

Procedure - The experiment was carried out in two sessions in the Arctic Chamber of the U. S. Army Natick Research and Development Laboratories, Natick, MA. The chamber was cooled to -20°F during the first session of the study and to -10°F during the second session. Table I lists in which session each goggle was tested.

Six subjects participated in each stage and tested six goggles. Each subject wore each of the six goggles once. The order of presentation was counterbalanced so that each subject wore the goggles in a different order.

The six subjects donned their goggles and immediately began jogging on a treadmill at a speed of about 5 miles per hour for 15 minutes. Three targets of different contrasts were displayed in front of the mill at a distance of 10-20 feet from the subjects, depending on their position on the mill, and illuminated to about 20 footlamberts. As the subjects ran, their goggles tended to fog and frost over. The subjects reported to the experimenter, standing beside the treadmill, when a target was no longer visible through the goggles. The times of these reports were recorded.

The targets were light gray circles on a white background; their contrasts were .05, .08, and .15. At a distance of 15 feet, the circles subtended 1.4 degrees of visual angle, and the background was 2.9 x 4.8 degrees visual angle.

Subjects - Nine U. S. Marines, members of a larger group of men who had volunteered to participate in an experiment carried out by the Biomedical Sciences Department of NSMRL, volunteered to be subjects in the present study as well. Three of the men participated in both stages of the study; the others participated in only one stage.

RESULTS

Table I gives the mean percent of the time during the 15-minute runs that each target was visible through each of the goggles. For example, during the six runs in which the G-12 goggle was worn, the lowest contrast target was visible to the six men for an average of 3 percent of the 15-minute periods; the highest contrast target was visible for 20 percent of the 15-minute periods. The solitary glass goggle is listed first in the table, followed by the three single-pane plastic goggles. The second group is composed of the five double-pane goggles, and the final group is made up of the three goggles which the manufacturers state have been treated to be fog-resistant. One of these is a single-pane goggle, and the other two are double-pane.

There are appreciable differences between the various goggles. The mean time the three targets were visible ranged from 13 percent with the glass goggle to 100 percent for the 2F-55 goggle. The differences in visibility through the various goggles were significant, according to an analysis of variance ($F = 12.6$, $p < .001$).

The differences are most marked with the low contrast target. According to a t-test for multiple differences among the means, the visibility of the low contrast target is significantly worse through the G-12 goggle than through any other goggle except the 1-21 goggle. Visibility of that target is better through the 2F-55 goggle than through any of the other goggles except the 2F-42 and 2-51. With the high contrast target, on the other hand, there are no significant differences between the goggles except for the G-12 which remained significantly poorer than the others.

The mean visibility improves systematically from the glass goggle to the single-pane, double-pane, and finally to the fog-resistant goggles.

The visibility of the target was a function, however, not only of the degree of fogging but also of the degree of transmittance. This varied from 12 percent for the glass goggle to 80 percent. Clearly, any difficulty in seeing the low contrast target through a low transmittance filter must be ascribed, at least in part, to that factor. Unfortunately, the glass goggles were also the most dense filters. The effect of transmittance on the visibility of the targets must, therefore, be assessed independently.

Table I. Mean percent of the time each target was visible through each of the goggles

Goggle*	Session	Target Contrast .05	.08	.15	Mean
Single Pane					
Glass - G-12	(1)	3 ±3.4	16 ±31.8	20 ±39.7	13
Plastic - 1-21	(1)	25	80	100	68
1-55	(2)	60	83	92	78
1-80	(1)	44	87	88	73
Mean		43 ±39.0	83 ± 27.6	93 ±19.9	73
Double Pane					
Plastic - 2-17	(2)	42	97	99	80
2-40	(1)	39	72	83	65
2-42	(2)	61	93	99	84
2-51	(2)	72	100	100	91
2-66	(1)	55	72	83	70
Mean		54 ±37.2	87 ±26.0	93 ± 22.1	78
Fog-Resistant					
Plastic - 1F-67	(1)	57	94	100	84
2F-42	(2)	88	100	100	96
2F-55	(2)	100	100	100	100
Mean		82 ± 30.0	98 ±7.8	100 ±0.0	93

* The number indicates the percent transmittance of each goggle.

First, it must be noted that the low contrast target was visible through all the goggles when they were unfogged. Second, there are three goggles which have very low transmittances, the G-12, 1-21, and 2-17. Yet the measures of visibility of the low contrast target through these three goggles range from 3 to 42 percent. An analysis of variance of the results through these three goggles shows them to be significantly different ($F = 45.3$, $p < .001$). Moreoever, an analysis of variance of the remaining nine goggles shows that the differences in visibility remain significant ($F = 3.3$, $p < .05$) despite the reduced range of transmittances. It is clear, therefore, that the differences in visibility are due mainly to differences in degree of fogging.

These results are quite similar to those of the previous experiment. In that study, the maximum target contrast which could not be detected by each subject at the end of 10 minutes was recorded at each ambient temperature. The correlation between these results and the visibility times in this study was -.79 ($p < .01$).

DISCUSSION

The ability of goggles to resist fogging is a critical charactistic. There is no question that if a pair of goggles becomes fogged, it will be removed, depriving the eyes of the protection the goggles were intended to provide. A problem with most goggles is that they do fog under certain conditions, and unless that can be eliminated, they will be used intermittently at best. For example, to study the effects of cold on the eye, Kolstad and Opsahl[3] examined cross-country skiers who had competed in a 90-minute race in Norway. In their report, they remarked that the skiers found it impractical to use goggles in such races, because they fogged and became encrusted with ice. The result, incidentally, was that 26 of the 39 skiers examined within 30 minutes of the end of the race were found to have damage to their eyes.

The results of this study, as well as the previous preliminary studies,[1] show that there are differences in the ability of different goggles to resist the fogging which tends to occur during strenuous activity in the cold. The glass filters, which have the advantage of resisting abrasion, are at a particular disadvantage. The glass has much greater specific heat than plastic, retains the cold to a much greater extent after having been cooled, and is thus much more prone to fog when moist air from perspiration or the breath strikes it.

Some of the goggles are advertised as being fog-resistant. The present results suggest that there are, indeed, some effective coatings, because those goggles turned out to be among the most fog resistant.

It is generally assumed that the double-pane goggles are more fog resistant. And, indeed, for the medium contrast target--for which transmittance is not as important a variable as for the low contrast target--it can be seen that of the best six goggles, five are double-pane. (The sixth is a single-pane goggle which the manufacturer says has been treated to resist fogging.) Conversely, of the worst six goggles, four are single-pane.

On the other hand, the differences in mean visibility time between the single- and double-pane goggles are not large. For the three plastic single-pane goggles, the mean time was 73%; for the five double-pane goggles which were not treated for fog-resistance, the mean time was 78%. The difference is not significant according to a t-test, and there are no significant differences between the eight goggles according to an analysis of variance.

Our primary conclusions are: 1) The protective goggles issued to the Marines (1-21) at the present time are among the poorer of these devices in resistance to fogging, as well as in some other characteristics.[1] 2) A satisfactory goggle should be treated for resistance to fogging, should be plastic rather than glass, should be comfortable, and fit over spectacles. 3) The best goggles were double-paned, but the advantage of the double-pane was small.

A few questions remain unanswered. One concerns the effectiveness of the antifogging cloths which are available. We do not know how long a given application of the cloth lasts, or how long the cloth itself lasts. Our previous investigation did show that these cloths, when new, were effective, at least for a time. Another question has to do with the effect of size and shape of the goggles. The two smallest spectacles, the G-12 and 1-21, were poor, but we do not know if their size contributed to the poor performance. Finally, we do not know if such small, non-significant differences as those between the groups of single- and double-pane goggles would increase over longer periods of time.

These results will be useful in deciding on specifications for an optimal set of goggles for issue to the Marines.

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REFERENCES

1. S. M. Luria, D. F. Neri, J. A. S. Kinney, and H. M. Paulson. Cold weather goggles: I. Optical evaluation. NSMRL Rep. No. 970, Jan 1982.

2. S. M. Luria. Cold weather goggles: II. Performance evaluation. NSMRL Rep. No. 978, Mar 1982.

3. A. Kolstad and R. Opsahl, Jr. Cold injury to corneal epithelium. Acta Ophthal. 47, 656-659, 1969.

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