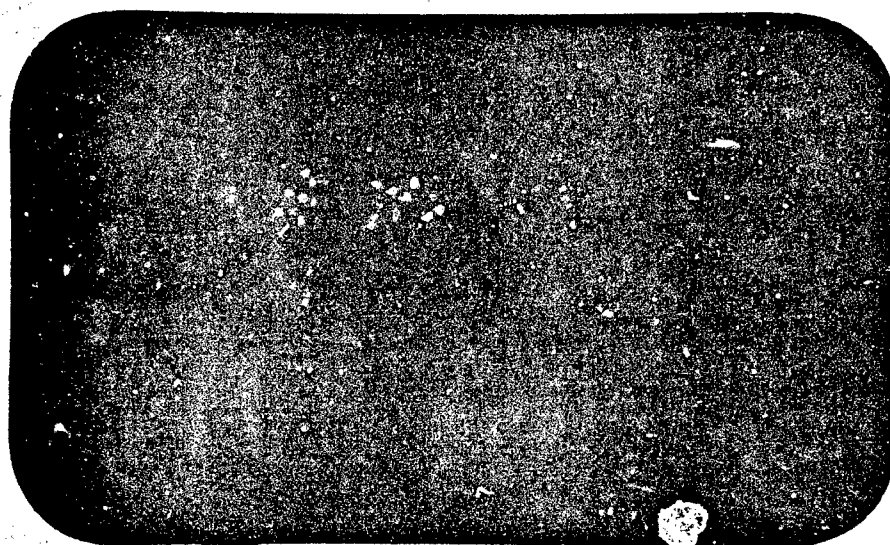


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RESEARCH MEMORANDUM

THE EFFECTS OF PROTECTIVE MASKING UPON SMOKE
GENERATOR AND FUEL SUPPLY TEAM PERFORMANCE

(An Analysis of an Experiment Conducted
By the U.S. Army Chemical Corps)

by

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INTRODUCTION

Combat may require troops to operate in environments rendered lethal by chemical, biological, and radiological warfare agents. As the protective mask must be worn if men are to survive in such environments, the Army needs to know how well men can perform their duties while wearing masks. Such information would enable Army planners and commanders to make better predictions of troop performance under conditions of CBR warfare.

Accordingly, the U. S. Army Chemical Corps Board is conducting a series of studies designed to determine initial and long-term effects of mask-wearing upon the combat efficiency of troops. This operation is designated JACKPOT.^{1/}

Late in 1957 the Human Resources Research Office was asked to assist in this exercise, and in the summer of 1958 the Training Methods Division conducted an experiment as part of Task PROTECT, designed to assess the effects of wearing masks on the performance of individual combat skills.^{2/} The study measured the decrement in performance due to wearing the M35 mask both initially and after five hours of masking, in each of seven different types of individual combat activities. On most of the activities studied the decrement was less than 10 per cent; for voice communication, however, losses of 20 per cent or more were common.

^{1/} The military requirement for this research is specified in the Department of the Army Combat Development Objectives Guide (""), 1959 revision, paragraph 1240a ("").

^{2/} William E. Montague, Robert D. Baldwin, and Andrew H. McClure, "The Effects of Wearing the CBR Protective Mask Upon the Performance of Selected Individual Combat Skills," HUMPRO report to be published.

The Chemical Corps Board was further interested in determining, as an additional project under JACKPOT, the effects upon troop performance of wearing the mask continuously for several days and nights. Plans for such a study were discussed with Training Methods Division personnel, and in October and November 1958 an experiment was conducted at Fort McClellan, Alabama, by personnel of the U. S. Army Chemical Corps Training Command. The data were analyzed by HumRPO. The completed analysis was transmitted to the Board on 11 March 1959, and an informal briefing and discussion were held. The present report is based on a part of this analysis.

PROBLEM

The main objective of this study was to determine the magnitude of any decrement in performance of smoke generator and fuel supply teams after four hours and after 68 hours of mask-wearing.

EXPERIMENTAL SITUATION

Sample

The subjects in this experiment were Smoke Generator Company enlisted personnel of the Chemical Corps Training Command at Fort McClellan. These soldiers had had widely varying amounts of previous experience in wearing protective masks in the course of their routine Chemical Corps training. Also they had had varying amounts of previous practice in performing the smoke generator and fuel supply jobs.

Design of experiment

Ten smoke generator teams and two fuel supply teams^{3/} were randomly assigned to two groups, designated A and B. These groups received the same training but with counterbalanced masked and unmasked trials in order to control for time-associated variables, such as weather and temperature. The experimental design of the study is shown in Figure 1.

During the first two weeks the men received periodic training in wearing the protective mask, and also in performing their jobs, though the mask was not worn while the jobs were being practiced.

Data collection was initiated during the third week. The groups wore masks for four hours a day, during which time their performance was timed; as a control they were also timed on four hours of unmasked job performance. As noted, Group A was unmasked when Group B was masked, and vice versa.^{4/}

The fourth and fifth weeks each consisted of a 68-hour bivouac. Group A was unmasked during the first bivouac but was masked during the second, while Group B followed a counterbalanced masking schedule. The jobs were never performed during the 68-hour bivouacs. After each bivouac, however, the teams performed their respective jobs for four hours, masked or unmasked as required.

^{3/} A smoke generator team is composed of two men; a fuel supply team, three men.

^{4/} The pre-bivouac experience (2nd and 3rd weeks) should not be construed as a necessary preliminary for men to "withstand" the masked bivouac. An additional group, similar except that it did not receive these two weeks of job practice and mask wearing, went directly into the 68-hour masked bivouac. When tested in the mask immediately following bivouac, this group performed the jobs without difficulty.

FIGURE 1
EXPERIMENTAL DESIGN

Sample

Type of Team	Number of Teams	
	Group A	Group B
Smoke Generator (2 men each)	5	5
Fuel Supply (3 men each)	1	1

Schedule of Activities

Week of Experiment	Activities	
1--Preliminary (20-24 Oct)	All men received an orientation to the study, had mask fitted, and practiced some mask wearing.	
2--Practice (28-30 Oct)	Both groups practiced jobs extensively (smoke generator job 21 times, fuel supply job 14 times). Both groups wore mask periodically, but not while performing jobs. (Scorers practiced timing job performance.)	
3--Test of 4-Hour Masking Effects (6-8 Nov)	On each of three days, time scores taken during 4 hours of masked job performances and 4 hours of unmasked job performances with the two groups counterbalanced.	
4--Test of 68-Hour Masking Effects (12-15 Nov)	<u>Group A</u> 68-hour bivouac followed by time scoring of jobs all while <u>unmasked</u> .	<u>Group B</u> 68-hour bivouac followed by time scoring of jobs all while <u>masked</u> .
5--Counterbalance for 4th Week (17-21 Nov)	Same as 4th week, but <u>masked</u> .	Same as 4th week, but <u>unmasked</u> .

Jobs Performed

Each type of team performed its own particular job. The time required to perform each of the tasks or job elements, and the total job, was measured to the nearest second by a trained observer with a stop watch.

The smoke generator job in this study consisted of all the operations required of a smoke generator team up to, but not including, actually making smoke. These operations include carrying the smoke generators from the vehicle to the site, walking back to the vehicle, pushing the barrels of fog oil fuel to the site, preparing the generator, and the reverse of all these activities to reloading the vehicles.

During the third week, the smoke generator teams performed their jobs eight times (four times masked, four unmasked) on each of the three days. After the fourth and fifth week bivouacs, each smoke generator team performed the job four times.

The fuel supply job in this study consisted of the operations required of a fuel supply team in handling 485-pound barrels of fog oil. These activities include loading a 2 1/2-ton truck with the barrels at the fuel dump, unloading the fuel on the road along a predesignated line, and reversing the operations to return the fuel to the dump.

The fuel supply teams performed the job of handling the 10 barrels of fog oil only half as frequently as the smoke generator teams performed their task. Thus, in periods during which the smoke generator job was performed four times, the fuel supply job was performed twice.

The total job performances utilized as criteria in the present study were measured under standardized conditions and represent operationally realistic military activities.

Climate

During collection of the data for this experiment in November, the climate at Fort McClellan was cool. The results should be interpreted as applying to daylight behavior under relatively ideal weather and temperature conditions, and should not be generalized to extreme environments, such as the arctic or tropics.

Masking Conditions

The model E13R9 protective mask was used in this study. During the masking period of the experiment, the mask was worn continually except for a two-minute water break every two hours during the day and a 15-minute break at meal times. During the 68-hour masked bivouac all troops slept in their masks and were monitored during the night by an observer. No shaving was permitted during the masked bivouacs.

Mask-wearing violations were very few. The troops were able to perform their jobs and morale appeared high throughout the experiment. Wearing the masks did not prevent the men from playing softball during non-working periods in the daily routine.

RESULTS

The extent to which performance is slowed up due to wearing masks is shown in Figures 2 and 3.^{5/} In these figures the short horizontal lines represent the mean per cent decrement (or increment)^{6/} associated

^{5/} The numerical values used in plotting the figures are listed in Appendix A.

^{6/} The per cent difference was computed according to the formula

$$\frac{\text{Masked Time} - \text{Unmasked Time}}{\text{Unmasked Time}} (100)$$

The resulting value is a decrement due to masking when the Unmasked Time is less than the Masked Time, and an increment when the Unmasked Time is greater.

FIGURE 2

THE EFFECTS OF MASKING: MEAN PER CENT DECREMENTS AND INCREMENTS, AND 95% CONFIDENCE LIMITS, FOR THE TOTAL JOB PERFORMANCE OF TEN SHOE GENERATOR TEAMS

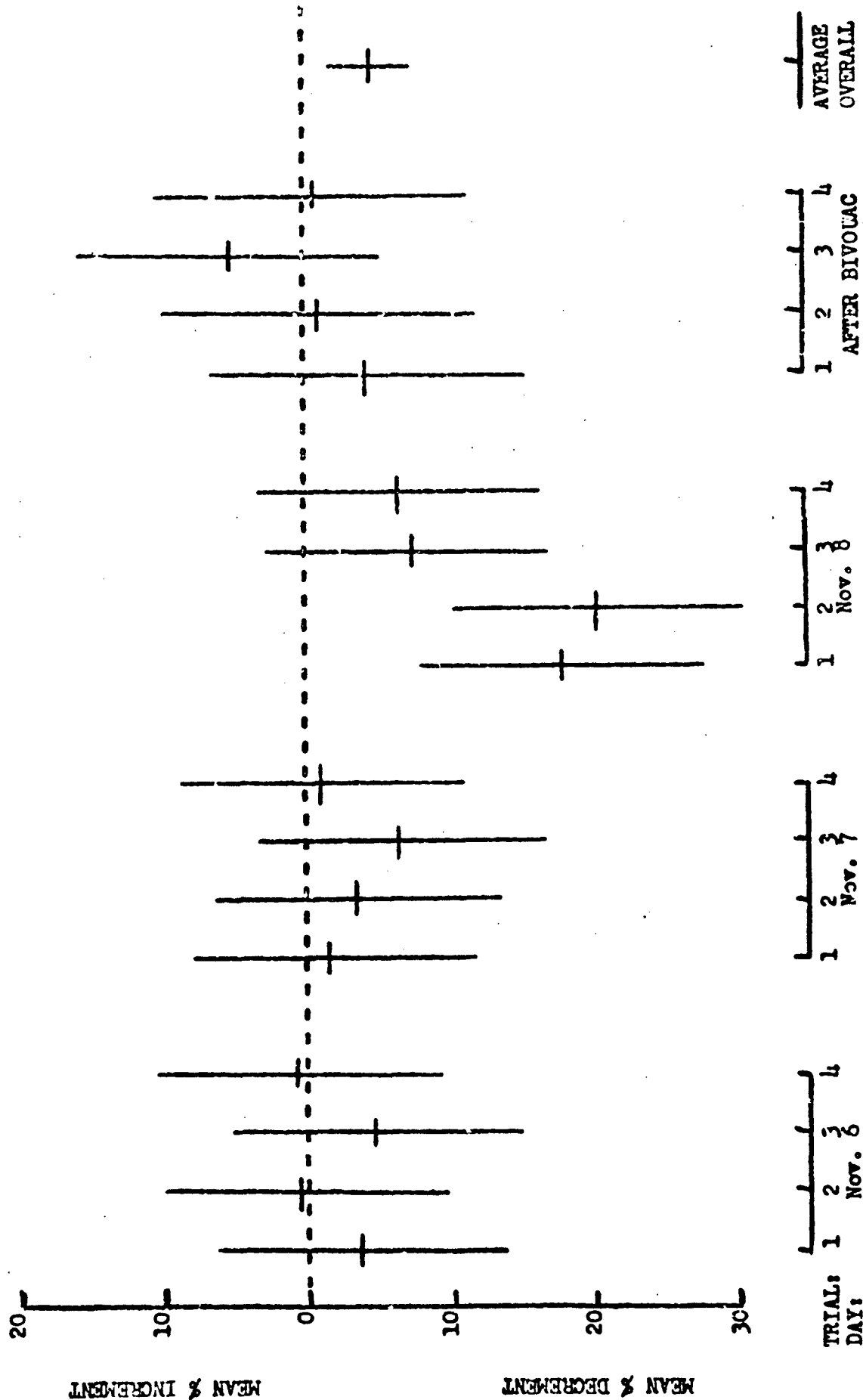
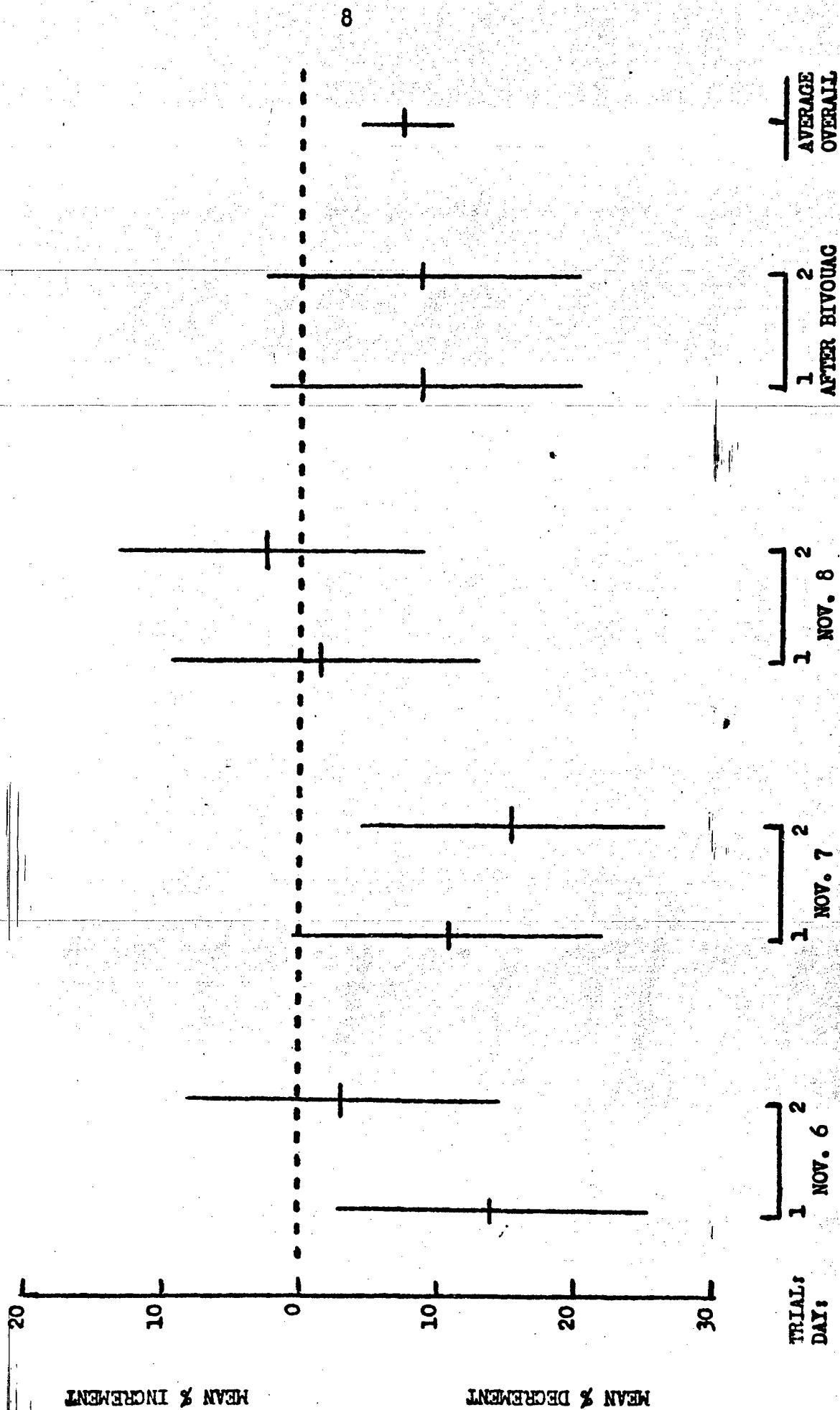


FIGURE 3

THE EFFECTS OF MASKING: MEAN PER CENT DECREMENTS AND INCREMENTS, AND 95% CONFIDENCE LIMITS,
FOR THE TOTAL JOB PERFORMANCE OF TWO FUEL SUPPLY TEAMS



with masking for the different trials during the third week and after the bivouacs. The average overall decrement for the total period is also shown. The vertical lines show the 95 per cent confidence limits around each decrement.

Figure 2 indicates an average overall masking decrement of about 5 per cent on the smoke generator job, while Figure 3 shows an average overall decrement on the fuel supply job of about 7 per cent. In Figure 2, trials 1 and 2 on November 8 show especially large decrements; though inquiry was made as to possible causes of these unusual effects, no satisfactory explanation has been found. In both figures the fluctuations in the decrement from trial to trial and from day to day appear to follow no systematic trend; for practical purposes they can be considered random.

Since all the teams received considerable practice in performing their jobs prior to the measurement of masking decrement, the magnitude of the present decrement is likely to be minimal when contrasted with the size of decrement that would be obtained from less well practiced teams. This is in light of the fact that less well trained habits are subject to greater disruption than are habits which have been thoroughly overlearned.

CONCLUSIONS

The following conclusions apply to the daylight performance, under cool pleasant weather conditions, of teams thoroughly practiced in their jobs and experienced in wearing the mask:

(1) On the average, the decrement in job performance caused by wearing the protective mask is about 5 per cent for smoke generator and fuel supply teams, though specific performances fluctuate widely about this value.

(2) When the protective mask is worn for four hours on each of three consecutive working days, there is no evidence to indicate that performance decrement either increases or decreases systematically. Nor is there evidence for any systematic change in the decrement as a result of a subsequent bivouac experience involving 68 hours of masking.

Appendix A

DECREMENTS IN TOTAL JOB PERFORMANCE
DUE TO MASKING

Table A-1

NOISE LEVEL DATA FOR NOISE GENERATOR TESTS
(Used in Figure 2)

<u>Day</u>	<u>Trial</u>	<u>Mean % Decrement</u>	<u>95% Confidence Limits (%)</u>
6 Nov	1	3.8	
	2	-0.2	
	3	4.8	
	4	-0.7	
7 Nov	1	1.6	± 2.9
	2	3.4	
	3	6.2	
	4	1.0	
8 Nov	1	17.9	
	2	20.2	
	3	7.4	
	4	6.4	
After Bivouac	1	4.1	+10.6
	2	0.9	
	3	-5.2	
	4	0.6	
Average Overall		4.6	± 3.0

Table A-2

JOB PERFORMANCE DATA FOR ONE FULL DAYLY PACE
(Used in Figure 3)

<u>Day</u>	<u>Trial</u>	<u>Mean % Decrement</u>	<u>95% Confidence Limits (%)</u>
6 Nov	1	13.9	
	2	3.0	
7 Nov	1	10.7	+11.1
	2	15.1	
8 Nov	1	1.3	
	2	-2.6	
after Sivouac	1	8.7	
	2	8.6	
Average Overall		7.3	+ 3.3