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HumRRRO

Technical Report 71

May 1961

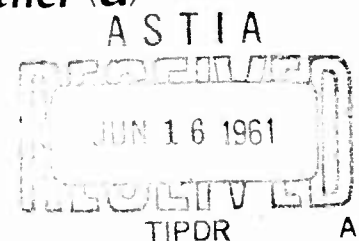
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Human Factors in CBR Operations: The Effects of CBR Protection Upon the Performance of Selected Combat Skills in Hot Weather (U)

by

William E. Montague and Richard I. Moren

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Training Methods Division

Under the Technical Supervision of

**The George Washington University
HUMAN RESOURCES RESEARCH OFFICE
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DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF RESEARCH AND DEVELOPMENT
WASHINGTON 25, D. C.

15 June 1961

CRD/J

SUBJECT: Human Factors in CBR Operations: The Effects of CBR Protection upon the Performance of Selected Combat Skills in Hot Weather

TO:

COMMANDER
ARMED SERV TECH INF AGENCY
ARLINGTON HALL STATION
ARLINGTON 12 VIRGINIA
ATTN TPCR

1. The attached report is furnished for your information and retention.

2. The objective of this study was to discover the effects on a soldier's combat performance during hot weather of wearing: one, the protective mask; and two, the permeable protective outfit (two-layer, chemically impregnated clothing including impregnated socks and gloves, treated field boots, butyl-rubber-coated cloth hood, and the protective mask).

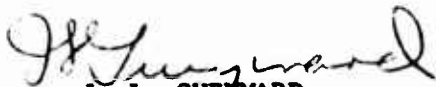
3. The information in this report has been incorporated in the report entitled, "Troop Test of CBR Defensive Means" (JACKPOT). Further, USCONARC will take the necessary action to incorporate CBR play in field exercises wherever possible.

4. The report is of vital interest to all combat and service units of the Armed Forces; and should be of interest to any agencies which may be involved in Civil Defense.

FOR THE CHIEF OF RESEARCH AND DEVELOPMENT:

1 Incl

HumRRO Tech Rpt 71
(PROTECT)


J. L. GUEYMARD

Lt Colonel, GS

Actg Chief, Human Factors Research Division

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AD <u>Accession No.</u> _____ Human Resources Research Office, The George Washington University, Washington, D.C. HUMAN FACTORS IN CBR OPERATIONS: THE EFFECTS OF CBR PROTECTION UPON THE PERFORMANCE OF SELECTED COMBAT SKILLS IN HOT WEATHER (U)—William E. Montague and Richard L. Moren (Training Methods Division) Technical Report 71, May 61, 44 pp.—illus (Contract DA-49-106-qm-1) DA Proj 095-SU-000 CONFIDENTIAL Report Troops were tested in hot weather under three conditions of CBR protection: in normal field uniform (no protection), wearing the model E13R9 mask, and wearing the entire permeable protective uniform (including the mask). The tests were: setting up and taking down smoke generators, road marching, running, rifle loading and unloading, rifle disassembly and assembly, rifle bore cleaning, spark plug changing, carbure marksmanship, radio communication, and unaided voice communication. It was concluded that, with proper safeguards, a great deal of useful military activity can be accomplished by men wearing the mask or the complete protective outfit, although the quality of performance will be lower than in normal uniform. If proper safeguards are not used, there is danger of heat injury to the personnel involved. Primary Field: Human Engineering; Psychophysical Factors in the Relation Between Man and Instruments, Machines, and Weapons. Secondary Fields: Psychophysiology of General Organic and Special Environmental Stresses and Unusual Conditions; Training and Education (Methods, Evaluation); General Psychophysiology (Sensory Discrimination, Perception, Motor Skills, and Proficiency).	CONFIDENTIAL 1. Protective clothing— climatic factors; military personnel— performance 2. Contract DA-49-106-qm-1	AD <u>Accession No.</u> _____ Human Resources Research Office, The George Washington University, Washington, D.C. HUMAN FACTORS IN CBR OPERATIONS: THE EFFECTS OF CBR PROTECTION UPON THE PERFORMANCE OF SELECTED COMBAT SKILLS IN HOT WEATHER (U)—William E. Montague and Richard L. Moren (Training Methods Division) Technical Report 71, May 61, 44 pp.—illus (Contract DA-49-106-qm-1) DA Proj 095-SU-000 CONFIDENTIAL Report Troops were tested in hot weather under three conditions of CBR protection: in normal field uniform (no protection), wearing the model E13R9 mask, and wearing the entire permeable protective uniform (including the mask). The tests were: setting up and taking down smoke generators, road marching, running, rifle loading and unloading, rifle disassembly and assembly, rifle bore cleaning, spark plug changing, carbure marksmanship, radio communication, and unaided voice communication. It was concluded that, with proper safeguards, a great deal of useful military activity can be accomplished by men wearing the mask or the complete protective outfit, although the quality of performance will be lower than in normal uniform. If proper safeguards are not used, there is danger of heat injury to the personnel involved. Primary Field: Human Engineering; Psychophysical Factors in the Relation Between Man and Instruments, Machines, and Weapons. Secondary Fields: Psychophysiology of General Organic and Special Environmental Stresses and Unusual Conditions; Training and Education (Methods, Evaluation); General Psychophysiology (Sensory Discrimination, Perception, Motor Skills, and Proficiency).	CONFIDENTIAL 1. Protective clothing— climatic factors; military personnel— performance 2. Contract DA-49-106-qm-1
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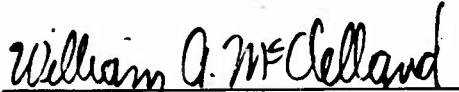
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**HUMAN FACTORS IN CBR OPERATIONS:
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by

William E. Montague and Richard I. Moren

Approved:


WILLIAM A. McCLELLAND
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Human Resources Research Office

The George Washington University
HUMAN RESOURCES RESEARCH OFFICE
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Technical Report 71
May 1961

Task PROTECT I

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(U) Dr. William A. McClelland, Director of Research for the Training Methods Division during the period of the PROTECT research, is now Deputy Director for General Operations and Personnel, Human Resources Research Office. He was succeeded by Dr. Arthur J. Hoehn as Director of Research for the Training Methods Division on 1 April 1960.

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BRIEF (U)

1. PROBLEM

a. Developments in CBR weapons systems have necessitated the development of protective masks and clothing for troops exposed to such agents. In certain situations, adequate protection would be accomplished by merely wearing the mask; in other circumstances, however, men might have to wear not only the mask but also the two-layer chemically impregnated clothing, including impregnated socks and gloves, treated field boots, and butyl rubber-coated cloth hood.

b. The U.S. Army Chemical Corps Board requested HumRRO to assist in the conduct of research aimed at discovering what effects wearing such protective items would have on men's combat performance. The main objective of this study was to explore, under hot weather conditions, the performance capabilities in combat activities of men in the CBR protective conditions of (1) wearing the mask, and (2) wearing the permeable protective outfit which includes the mask.

2. METHOD

a. Ten military skills or activities were chosen which were judged to be important now and under probable future combat conditions at least up to 1965. Tests of these activities were administered to soldiers in three degrees of CBR protection: (1) wearing the ordinary field uniform (no CBR protection), (2) wearing the mask, and (3) wearing the entire permeable protective outfit. The mask used was the model E13R9, which is almost identical with the model standardized for issue as the M17. The effects of each of the two protected conditions were determined by comparing the performance of men in these respective conditions with that of men in the control condition of normal field uniform. Two different types of scores were used: (1) conventional time or accuracy scores, and (2) heat exhaustion dropout scores, the diagnosis of heat exhaustion always being made by a medical officer.

b. The subjects were 149 Chemical Corps enlisted troops from smoke generator companies: 104 men were tested at Fort McClellan, Ala., and 45 at Dugway Proving Ground, Utah. The tests were conducted in June, July, and August, 1959. The temperature at both locations was hot, typically around 90°F, but at Dugway it was less humid than at Fort McClellan.

3. CONCLUSIONS. The results of the study support the conclusion that, if proper safeguards are utilized, a great deal of useful military activity can be accomplished by men wearing the mask or the complete protective outfit, although the level or quality of performance will not be as high as in the normal (unprotected) condition. If proper safeguards are not used, however, heat injury to the personnel involved is an ever-present danger.

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SUMMARY AND RECOMMENDATIONS

(U) PROBLEM

Modern developments in chemical, biological, and radiological (CBR) weapons systems have necessitated the continued development of protective masks and clothing to protect the lives of troops exposed to such agents. Under certain conditions of CBR warfare, troops might have to wear only the field protective mask. Under more extreme degrees of hazard, they might have to wear the complete permeable protective outfit (the two-layer, chemically impregnated clothing including impregnated socks and gloves, treated field boots, butyl rubber-coated cloth hood, and field protective mask.)

The U.S. Army Chemical Corps Board requested HumRRO to assist in the conduct of research aimed at discovering what effects the wearing of such protective items would have on men's combat performance. It was agreed that the research should be a joint Board-HumRRO effort in which the Board would be responsible for collecting the data, providing the troops to serve as subjects, and supplying the necessary logistical support; HumRRO, in turn, would be responsible for the technical considerations of research design and test construction, for indoctrination of the military project officers in technical matters, and for analysis of the data and preparation of a report.

The main objective of this study was to explore the performance capabilities in combat activities, under hot weather conditions, of men wearing (1) the CBR protective mask and (2) the complete permeable protective outfit which includes the mask. Specifically, it was necessary to determine if certain common types of military activities *can* not be performed in hot weather by men while CBR-protected, and also to measure any losses in combat proficiency for such tasks as *can* be so performed.

The intent was to determine how well CBR-protected personnel can withstand the effects of carrying out combat activities under extreme conditions of hot weather, since wearing the protective items in hot weather would make it especially difficult for the body to rid itself of its excess heat. A secondary mission was to suggest ways, derived from observation of the troops in the field, for improving the training of troops in the performance of their duties while under conditions of CBR protection.

A previous HumRRO study¹ dealt with the effects on performance of the mask only. That portion of the present study dealing with the "mask alone" is thus to some extent a repetition of earlier HumRRO work. This repetition was considered desirable to provide evidence to supplement the earlier results.

(U) METHOD

Ten military skills or activities were chosen which were judged to be important now and under probable future combat conditions at least up to 1965. Individual or two-man team performance tests of these activities were administered to soldiers under

¹William 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*, Technical Report 57, Human Resources Research Office, Washington, June 1959.

SUMMARY AND RECOMMENDATIONS

three conditions of CBR protection: (1) wearing the ordinary field uniform (no CBR protection), (2) wearing the mask, and (3) wearing the entire permeable protective outfit. The mask used in this study was model E13R9, which is almost identical with the model standardized for issue as the M17.

The effects of wearing the mask were determined by comparing the performance of men wearing the mask with the performance of men in ordinary uniform, both tests being administered under similar conditions. The effects of wearing the permeable protective outfit were similarly determined by comparing the performance of men wearing the protective outfit with that of men wearing ordinary clothing. The ability of men to remain, and function, in the protective equipment for several days and nights was also explored.

The ten military activities tested were (1) setting up and taking down smoke generators, (2) performing road marches, (3) running, (4) loading and unloading the rifle, (5) disassembling and assembling the rifle, (6) cleaning the rifle bore, (7) changing motor vehicle spark plugs, (8) firing the carbine, (9) receiving information by radio, and (10) receiving information transmitted by the unaided voice.

Each of these tests was administered and scored in a standard manner to constitute an objective measure. Most of the tests yielded a score for every individual. The Smoke Generator and Running tests, however, gave a score for each two-man team. The Road March Test (and, in some instances, the Smoke Generator Test) gave each man only a "pass-or-fail" score which provided a rough quantitative basis for detecting performance limitations—the percentage of individuals who could not complete the activity because of heat exhaustion (dropout rate). Thus two different types of scores were used: (1) time or accuracy scores and (2) heat exhaustion dropout scores. The diagnosis of heat exhaustion was always made by a medical officer.

The subjects were Chemical Corps enlisted troops from smoke generator companies. In all, 149 men were tested—104 at Fort McClellan, Ala., and 45 at Dugway Proving Ground, Utah. The data were collected in the summer of 1959; the Fort McClellan tests were conducted in June and July, the Dugway tests during July and August. The weather at both locations was hot, typically around 90° F., but at Dugway it was less humid than at Fort McClellan. No rain fell during the period of the tests.

At each location the men were randomly assigned to the three conditions: no CBR protection, mask, and permeable protective outfit. The procedure followed was to have the subjects engage in a particular test, during performance of which they were carefully observed. If no difficulties occurred, the testing continued as planned. If men began to drop out from heat exhaustion, however, the work was stopped or reduced in intensity and medical treatment was administered as necessary.

Thus it was possible to ask two different questions about the military performance of CBR-protected troops in hot weather operations: (1) Is it possible (or militarily practical, in view of health hazards) for troops to perform a particular type of activity while wearing the protective equipment? And, if it is possible (or practical), (2) how much decrement or loss in proficiency in performing the particular activity is caused by wearing the mask or the protective outfit?

FINDINGS

- (C) 1. During one administration of the Smoke Generator Test, 40 per cent of the men in the protective outfit dropped out from heat exhaustion. Likewise, during one administration of the Road March Test, 31 per cent of the men in the protective outfit dropped out with heat exhaustion. Dropouts were much less frequent in the masked group, and no dropouts occurred in the normally clothed group.
- (U) 2. Throughout the remainder of the study there were only a few additional occurrences of heat exhaustion, and about as many occurred in the normally clothed group as in either of the other groups.
- (C) 3. The performance of men in the masked condition was typically slower or less accurate than the performance of men in normal uniform. Performance of men wearing the permeable protective outfit was, in turn, inferior to that of men in the masked condition. The protective gloves slowed men's performance in activities requiring finger dexterity. The mask interfered greatly with voice communication, and the addition of the hood increased this interference.
- (C) 4. When given occasional unprotected short breaks for food or water, men were able to wear the mask or the permeable protective outfit, awake and asleep, for 81 consecutive hours. Some men tended to remove the mask in their sleep and had to be awakened to remask.

CONCLUSIONS

- (C) 1. The main conclusion of this study is that, unless safeguards are observed, there is a definite danger to men's health, operational effectiveness, and survival in requiring them to perform physically strenuous activities in hot weather while wearing the permeable protective outfit. The common danger in such situations is heat exhaustion, although, under particularly unfavorable conditions, heat stroke—with its high mortality rate—should probably be expected. When the mask is the only protective item worn these dangers are greatly reduced, although they are still greater than in the completely unprotected state (normal field uniform).
- (C) 2. Even in hot weather and in full protection, however, troops can often perform useful amounts of physical work if they are careful to "pace" themselves in their activities, and if they and their leaders understand and apply the principles of heat injury prevention.
- (C) 3. When conditions are such that the troops remain operational and healthy, wearing the CBR protective mask typically reduces the level or quality of performance, and wearing the permeable protective outfit reduces the performance level even further. Voice communication is greatly impaired by the mask, and even more by the full protective outfit, due to the hood.
- (U) 4. The mask, and the full protective outfit, can be worn for at least three consecutive days and nights with no ill effects if provision is made for food, water, and elimination (unprotected breaks).

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SUMMARY AND RECOMMENDATIONS

5. The limitations imposed on the performance of military activities by wearing the CBR protective equipment suggest the desirability of certain modifications in Army training. Specifically:

- (U) a. A thorough indoctrination¹ in the danger and prevention of heat injury should be given to all officers and troops scheduled for participation in combat operations or training exercises requiring the wearing of the CBR protective mask or permeable protective outfit.
- (U) b. Troops and troop leaders should be given training in performing their specific MOS duties while wearing the mask or the full protective uniform. Such training should include experience in hot weather operations (under medical supervision). To maintain each individual's military skills at high levels of proficiency under such conditions, the practice should be repeated periodically.
- (C) c. Because of the serious interference of the mask and the hood with unaided voice communication, training should stress the use of radios and hand-and-arm signals to maintain adequate communication in operations involving troops wearing the mask or the permeable protective outfit.

RECOMMENDATION

- (U) It is recommended that personnel with responsibility in operational planning, training, medical care, and development of doctrine consider this study's findings and conclusions with regard to the degradation of troop performance as a result of wearing the CBR protective equipment.

¹Refer to Department of the Army, *The Etiology, Prevention, Diagnosis, and Treatment of Adverse Effects of Heat*, Technical Bulletin MED 175, August 1957.

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**DESCRIPTION
OF THE RESEARCH**

**HUMAN FACTORS IN CBR OPERATIONS:
THE EFFECTS OF CBR PROTECTION UPON THE PERFORMANCE
OF SELECTED COMBAT SKILLS IN HOT WEATHER (U)**

(U)

PROBLEM AND BACKGROUND

Developments in chemical, biological, and radiological (CBR) warfare agents and delivery systems have greatly increased the offensive capabilities of modern armies. To protect the lives of troops engaged in such warfare, the Department of the Army directs that all elements maintain a defensive capability; therefore, protective masks and protective clothing have been developed to meet this need for personal defense. The protective mask is designed to enable men to survive exposure to CBR agents that enter the body through the nose, mouth, or eyes; the protective clothing is designed to guard men against CBR agents that enter the body through the skin. Since future warfare might require soldiers to wear either the protective mask or the permeable protective outfit (mask plus protective clothing), it is desirable to determine what effect wearing such items has upon men's performance.¹

Previous research² indicated that the wearing of the mask alone produced no apparent ill effects upon the health of the troops, even when it was worn for several consecutive days and nights. Although wearing the mask tended to lower the quality and speed of performance, wearers were in no way incapacitated as a result of engaging in various military activities while masked. This was true even when the dry-bulb temperature was as high as 94° F. in the shade and the activity was the strenuous task of running at top speed for 220 yards over obstructed terrain.

The purpose of the present research was to explore the implications for human performance of wearing not merely the mask, but the entire permeable protective outfit. Chemical Corps personnel had reasoned that, since the permeable protective outfit covers all main skin surfaces with two layers of chemically impregnated cloth, strenuous hot weather operations should constitute an extreme test to reveal any limitations imposed on human performance by reducing the body's ability to lose its excess heat. Hot weather conditions were selected for study because the heat loss problem was believed to be so critical with regard to use of the protective equipment. It must be recognized that other extreme conditions, such as wet cold climates, might impose other limitations on the use of protective gear.

¹Department of the Army, *Combat Development Objectives Guide (U)*, Washington, May 1958 (revised October 1959) (SECRET), p. 1281.

²William 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*, Technical Report 57, Human Resources Research Office, Washington, June 1959; also, Richard I. Moren and William E. Montague, *The Effects of Protective Masking Upon Smoke Generator and Fuel Supply Team Performance*, Research Memorandum, Training Methods Division, Human Resources Research Office, Washington, April 1959.

The U.S. Army Chemical Corps Board requested HumRRO assistance in the conduct of the research. As a result of discussions between representatives of the Chemical Corps Board and members of the HumRRO Training Methods Division, it was agreed that the research should be a joint effort in which the Board would be responsible for collecting the data, supplying troops to serve as subjects, and providing logistic support of the operation; HumRRO, in turn, would be responsible for the technical considerations of research design and test construction, for indoctrination of the military project officers in technical matters, and for analysis of the data and preparation of a report. It was further determined that the research would be conducted at two Chemical Corps installations, Fort McClellan, Ala., and Dugway Proving Ground, Utah.

The research problem may be indicated by the following questions:

- (1) Under hot weather conditions, does the wearing of the permeable protective outfit (or of the mask alone) place any limitations, for reasons of health or safety, upon the military activities of troops? If so, what is the nature of such limitations, and what can be done to minimize such dangers?
- (2) For activities and conditions that are within acceptable health or safety limits, how great is the loss or decrement in performance for various types of military activities due to the wearing of the permeable protective outfit (or the mask)? Which combat activities are seriously impaired by the permeable protective outfit (or by the mask)? What kind of training would be likely to improve the performance of men wearing such protective items?
- (3) Can men spend as much as several days and nights working and sleeping in the permeable protective outfit (or the mask)?

The mask used in this study was the E13R9, which differs only slightly from the model standardized for issue as the M17.¹

(U) SELECTION AND MEASUREMENT OF COMBAT ACTIVITIES

Activities Selected for Testing

The criterion tests used to determine the effects on performance of wearing the protective items were based on 10 activities selected to represent various types of tasks soldiers often must perform in combat. For each activity, procedures were established so that each test could be administered and scored objectively. Three of the tests, designed to be physically strenuous, measured large-muscle activities. The remaining seven tests, designed to be nonstrenuous, sampled manual dexterity,

¹The differences are as follows: (a) The outlet valve seat is stamped aluminum on the E13R9, die-cast aluminum on the M17; (b) the inlet tap valve assembly has a four-spoke seat on the E13R9, a six-spoke seat on the M17; (c) on the M17 the nose-cup welt is slightly enlarged, the inlet valve disks are slightly enlarged and thickened, and the nose-cup valve disks are slightly thickened; (d) "outsert" lenses were developed for the eye pieces on the M17 to prevent fogging in cold weather.

hand-eye coordination, and auditory skills. By comparing the performance of men in normal field clothing with that of men wearing the mask, the effects of masking would be determined. Similarly, the effects of full protection would be determined by comparing the performance of groups normally clothed with that of groups wearing the permeable protective outfit.

Each test was arranged so that the men in each group—normally clothed, masked, or fully protected—could be scored either in terms of proficiency or in terms of the dropout rate. For example, if all men were able to perform a particular activity, measures of each man's proficiency (speed, accuracy, and the like) could be obtained. If, however, some men were unable to complete the activity—for example, because of heat exhaustion—the relative frequency of failures (the dropout rate) in the normal, masked, and fully protected groups would be utilized as a measure of incapacitation due to wearing the protective items.

Smoke Generator Test

In combat, men sometimes have to perform tasks requiring them to handle, transport, and assemble or manually adjust heavy items such as crew-served weapons, automotive equipment, or gasoline drums. To represent such a class of activities, the Smoke Generator Test was administered at Fort McClellan. The test was designed to measure the ability of a two-man team to carry and set up two smoke generators, supply them with fuel, get them ready to make smoke, and then, reversing these procedures, dismantle and return the equipment to its original location.

The specific procedure followed by each team was:

- (1) A smoke generator (weighing 156 lbs.) was picked up from a trailer and carried to a position 30 yards away.
- (2) A barrel of fog oil (weighing 485 lbs.) was tipped over, rolled to the generator, and tipped up.
- (3) The generator was prepared for operation.
- (4) A second generator was carried to position.
- (5) A second barrel was tipped and rolled to position, then tipped up.
- (6) The second generator was prepared for operation.

The above sequence was then reversed, until both generators and both fuel barrels were in their original positions at the trailer.

A man equipped with a stop watch was stationed at the 30-yard position and timed the performance of these operations. The timer also checked to be certain that several mechanical steps necessary for smoke generation were actually performed.

Road March Test

Mobility is of fundamental importance in combat. Since troops who cannot perform road marches, or cannot perform them at reasonable speed, are of limited military value, the Road March Test was designed to measure the road mobility of troops in a foot march. The test was administered both at Fort McClellan and at Dugway Proving

Ground. The scoring system was "pass" or "fail," depending upon whether the man completed the march or had to drop out.¹

The rate of march was set at the discretion of the troop leader. At Fort McClellan the distance marched was five miles, and the time required was two hours, including breaks. At Dugway Proving Ground the march was four miles in 1 3/4 hours, again including rests. At both locations the march was made along the shoulders of roads or on trails. The ground underfoot was dry and suitable for marching. The terrain was generally flat with occasional small slopes.

Running Test

In combat soldiers sometimes have to run for varying distances. In this test, administered at Fort McClellan, the men were required to run for 800 yards (nearly half a mile) on a road having a smooth, flat surface. They were started two at a time (smoke generator teams) and were instructed to run as fast as they could while still completing the entire distance. The men were also warned that, after completing the Running Test, they would have to perform three trials of the strenuous Smoke Generator Test. Although the two team members were not instructed to do so, most teammates ran the distance together. Each two-man team was scored in terms of the time required for both members of the team to run the 800-yard distance (in effect, the time of the slower man).

Rifle Loading and Unloading Test

The fundamental combat skill of ability to load and unload weapons was tested at Fort McClellan. In the first phase, the soldier was required to unsnap a pouch on his cartridge belt, draw out an eight-round clip of dummy ammunition, and load an M1 rifle. His score was the number of seconds elapsing between the initial unsnapping of the pouch and the final closing of the rifle bolt. In the second phase of the test, the man had to open the bolt of the weapon, depress the clip-release button and remove the clip, reload the loose rounds into the clip, insert the clip into the pouch on his belt, close the pouch, and snap it. Time was measured from the opening of the rifle bolt to the final snapping of the pouch. Both the loading and unloading phases of this test were initiated with the soldier standing at port arms.

Rifle Disassembly and Assembly Test

Field stripping and reassembling weapons, another important requirement of combat, was tested at Fort McClellan. The first phase required the soldier to disassemble the rifle. Time was measured from the opening of the butt plate (to obtain the rifle tool) to the removal of the bolt and other parts from the trigger housing; the gas cylinder assembly was not removed. The second phase required the soldier to reassemble

¹It had been anticipated that a man would begin to "straggle" or drop behind his formation more and more until he eventually stopped. This did not happen. Men remained with their formation until the moment of dropout, when they sat or lay down.

the weapon, time being measured from the command to commence until the trigger guard was snapped shut in the final stage.

Both phases of the test were conducted with the man sitting before a shelter half placed on the ground to prevent the loss of small parts. A screw driver was provided to assist in opening the butt plate and pushing loose the trigger-housing pin.

After the rifle had been reassembled and the time had been recorded, a monitor checked to make certain that the bolt could be operated; in the one or two instances in which the weapon failed to pass this inspection (indicating improper assembly), the rifle was disassembled and the assembly phase was repeated and retimed.

Rifle Bore Cleaning Test

Combat soldiers must be able to clean their weapons in a reasonable amount of time. This was a test of speed in cleaning the bore of the M1 rifle, administered at Dugway Proving Ground. The soldier was required to remove the oiler and thong case from the butt of his rifle, remove the thong from the case and drop the end of the thong through the rifle bore, put some oil on a patch, insert the patch in the patch holder, and draw the patch through the bore. Time was measured from the opening of the butt plate to the emergence of the patch from the rifle muzzle. In a few situations the thong broke; then a new thong was supplied and the entire operation was repeated from the beginning and retimed.

Spark Plug Changing Test

The performance of activities involving gross mechanical manipulation—as in automotive maintenance—is an ability required of some soldiers. This test, administered at Dugway Proving Ground, measured the time needed for a man to remove and replace a set of four spark plugs in the engine of a quarter-ton vehicle.

At the command to begin, the monitor started his watch and the subject began to disconnect the leads and unscrew the plugs with a spark plug wrench which was provided. The four spark plugs were set aside as they were removed and four others were installed, tightened, and connected to the leads. After the last lead was connected, the monitor stopped his watch and recorded the elapsed time. Within the limits indicated, each soldier was allowed to use any method he preferred to accomplish the task, although he was instructed to emphasize speed.

Carbine Test

The important combat skills of speed and accuracy in marksmanship were tested at Dugway Proving Ground. The Carbine Test measured the speed and accuracy with which men can aim and fire the carbine at a designated target.

The soldier, followed by a scorer, walked down a path toward five distant but clearly visible silhouette targets (type E), numbered 1 through 5. At a range of about 150 yards, the scorer designated a target

(e.g., "Fire on three!") and, on the number, started his watch. The soldier stopped, brought his carbine to his shoulder, aimed, and fired at the target. As the report sounded, the scorer stopped his watch and recorded the elapsed time. On the scorer's command, the advance was then resumed. This procedure continued until the soldier had fired twice at each of the five targets (a total of 10 shots). The scorer designated the targets in scrambled sequence. A target was designated every 8 to 12 yards as the soldier advanced, and the last shot was fired at a range of about 50 yards. The men were instructed to try for both speed and accuracy; time and number of hits were the two scores obtained on this test.

Radio Test

Radio communication was tested because it is necessary in many military operations. This test, given at Dugway Proving Ground, measured the intelligibility of voice messages transmitted by the AN/PRC-10 radio. The subject listened to two types of material: (1) plain-language commands or messages ("Enemy mortars behind old church") and (2) artificial or "code" messages, consisting of random sequences of letters from the military phonetic alphabet ("INDIA, X-RAY, KILO, ROMEO, QUEBEC").

The material was transmitted by a soldier who was selected for clarity of voice and who was thoroughly familiar with radio procedure. The sender delivered half the messages while masked and half while not masked, according to a preset random schedule. The listeners were instructed to write down what they heard, or what they guessed each message to have been, and to record the initial letter of each of the phonetic alphabet words they thought had been transmitted (e.g., "B" for "BRAVO"). Each man therefore received two types of scores: the number of plain-language commands or messages correct (highest possible score, six), and the number of phonetic alphabet letters correct (highest possible score, 30).

Voice Commands Test

Because of the importance of voice communication in most types of military actions, particularly at the platoon and squad level, this test was included to measure the intelligibility of short commands or messages transmitted over varying distances by unaided voice. It was conducted at Dugway Proving Ground. The messages were of the type used in the plain-language portion of the Radio Test.

A noncommissioned officer, selected for ability to deliver vocal orders loudly and clearly, shouted the messages from a central position, rotating his "facing" 90° between messages. As with the Radio Test, the speaker delivered the messages in random sequence, half while masked and half while not masked. A blast on a whistle preceded each message to alert the soldiers that a message was about to be transmitted. To compensate for wind direction, the listening soldiers were stationed around the speaker on the circumferences of three concentric circles with radii of 30, 60, and 90 yards. The soldiers shifted positions twice so that each received two messages at each of the three

distances. The listeners were instructed to write down what they heard, or what they guessed each message to have been. The maximum possible score at each of the three distances was two messages correct.

Types of Performance Measured

The tests included in this study sampled a wide variety of performances. The Smoke Generator Test involved heavy manual labor and gross manual dexterity. The Road March Test required sustained physical activity, particularly of the legs. The Running Test placed a more intense stress on the legs, lungs, and circulatory system, although for a shorter period of time. The Spark Plug Changing, Rifle Loading and Unloading, Rifle Disassembly and Assembly, and Rifle Bore Cleaning tests required manual dexterity in manipulating mechanical parts of various sizes and shapes. The Carbine Test involved delicate hand-eye coordination. The Voice Commands and Radio tests required auditory perception under varying acoustical conditions.

These various activities were sampled so that the results of the study would apply to many of the different types of abilities required of combat soldiers. Not all types of activities were sampled, however; for example, target detection, decision making, and map reading skills were not represented.

In addition, to measure specific military activities the study assessed the ability of men to perform military duties while spending as much as several days and nights in the protective equipment. Some of the tests were administered—several of them repeatedly—after the men had spent hours, or days, in the experimental conditions.

RESEARCH PROCEDURES

(U) Experimental Design

At every point in time during the period of testing, it was necessary to have comparable groups of men in each of three experimental conditions—(1) normal clothing, (2) mask only, and (3) the permeable protective outfit—to ensure that performance comparisons would be based on comparable situation factors.

Another consideration bearing on the choice of experimental design was that of obtaining as large a sample of observations as possible. Since the number of troops available as subjects was limited, the only way to increase the number of observations was to test the men more than once. Accordingly, in the designs chosen every man was assigned, at different times, to at least two of the experimental conditions, and some men were assigned to all three. It was recognized that changes occurring in the field might preclude carrying through such a plan; nevertheless, the possibility of gaining the statistical advantages of such an increased observational base justified the attempt. Since circumstances in the field did require modification of the initial research plans, the designs will be described in their final forms as actually utilized.

The study was conducted in the summer of 1959 at two locations—first at Fort McClellan during June and July, and about three weeks later at Dugway Proving Ground, during July and August. In general, the testing at Fort McClellan imposed more strenuous or more precise physical demands on the troops than did the testing at Dugway, while the testing at Dugway included a wider variety of military activities.

The troops who served as subjects of the research had been in training with their units for several weeks preceding the study. This training, including calisthenics, road marches, and marching at double time, acclimatized the men to the performance of strenuous physical activity in hot weather.¹

During the study, water was liberally supplied and the men were encouraged to drink it at least every two hours and as often as every 15 minutes, depending upon the intensity of the work. Salt, in the form of tablets or in solution in the water, was also plentifully supplied.

Since no optical inserts for the masks were available, only men who did not wear glasses were included in the study.

Throughout the study, the troops were checked periodically by their officers to ensure that the protective equipment was being worn as scheduled.

Strenuous Activity Experiment at Fort McClellan

(U) The design for the portion of the study conducted at Fort McClellan is shown in Figure 1. In the experiment dealing with strenuous activities, a group of 80 men was used (40 two-man smoke generator teams, 20 from each of two Smoke Generator Companies). For the initial testing stage, the 40 teams were randomly assigned to the three experimental conditions: normal uniform (12 teams), mask only (12 teams), and permeable protective outfit (16 teams). A larger number of teams was assigned to the group which was to wear the permeable protective outfit during the initial stage of the study, since it was expected that the full-protection group would be most likely to lose men as dropouts due to heat exhaustion. All men received preliminary experience in wearing the mask and the protective uniform during the week before testing began.

(U) On the morning of 29 June the men went into the field—each wearing the type of clothing assigned him for the experiment—and set up tents and facilities for bivouac. In the afternoon they performed two trials of the Smoke Generator Test. Since quite a few men had trouble performing the second test (mainly as a result of heat exhaustion), testing was suspended for the day and the men bivouacked overnight in tents. In the morning of the following day (30 June), the men took the Road March Test. As there were additional cases of heat exhaustion, no more

¹According to Army doctrine, a period of five to seven days is required to acclimatize troops who, as in the present study, are not basic trainees. See Department of the Army, *The Etiology, Prevention, Diagnosis, and Treatment of Adverse Effects of Heat*, Technical Bulletin TB MED 175, August 1957, p. 5; also, Headquarters, Department of the Army, *Prevention of Heat Injury*, Circular 40-6, April 1960, para. 2c.

**Fort McClellan Experiments to Evaluate the Effects
of CBR Protection on Troop Performance in Hot Weather**

A - Strenuous Activities Experiment

Date	Task	Troops Involved		
		12 Two-Man Teams	12 Two-Man Teams	16 Two-Man Teams
22-26 Jun	Familiarization With Protective Items	All troops received experience in wearing the mask and the permeable protective outfit		
29 Jun	Two Trials of Smoke Generator Test	Troops were tested in their respective experimental conditions:		
30 Jun	Road March Test			
		Normal Uniform	Mask	Permeable Protective Outfit
7 Jul	One Trial of <i>Half</i> of the Smoke Generator Test	Troops spent 81 consecutive hours in their respective experimental conditions:		
8 Jul	Road March Test; One Trial of <i>Half</i> of the Smoke Generator Test			
9 Jul	Running Test; Three Trials of Smoke Generator Test			
		Permeable Protective Outfit	Normal Uniform	Mask

B - Manual Dexterity Experiment

Date	Task	Troops Involved	
		12 Men	12 Men
1 Jul	Rifle Loading and Unloading Rifle Disassembly and Assembly	Normal Uniform	Mask, Hood, and Gloves
	Rifle Loading and Unloading Rifle Disassembly and Assembly	Mask, Hood, and Gloves	Normal Uniform

Figure 1 (U)

tests were given that week. While the men were wearing the protective equipment, two-minute unmasked breaks were permitted every two hours (or as often as every 15 minutes during strenuous activities), and 15-minute unmasked breaks were permitted at meal times. Short, unprotected latrine breaks were also permitted as necessary for the men in the permeable protective outfits.

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(U) For the following week the three groups exchanged experimental conditions¹ as indicated in Figure 1. On 7 July, each two-man team performed one trial of half the Smoke Generator Test (hand-carrying one generator and rolling one drum of fog oil the standard distance, making all connections, and then returning these items to their original positions). A 20-minute rest break, including a two-minute unmasked break, was given between the setting-up and the taking-down phases. This was repeated on 8 July, when the troops also performed the Road March Test. On 9 July the men performed the Running Test, followed immediately by three trials of the full-scale Smoke Generator Test (with two-minute unmasked breaks between trials).

(C) During this last week of the Fort McClellan experiment, the men remained in their respective experimental conditions continuously for about 81 hours under bivouac conditions, sleeping in the protective equipment assigned (including masks and hoods). Breaks were permitted on the same basis as in the previous week. Some men tended to remove the mask in their sleep and had to be awakened to remask.

(U) Manual Dexterity Experiment at Fort McClellan

A small separate experiment (see Figure 1) was conducted at Fort McClellan on 1 July to assess the effects of wearing the permeable protective outfit upon men's ability to manipulate small mechanical parts. The intent was to measure only the direct interference of the protective uniform. Since it was believed that such interference would be mediated only by the mask, the hood, and especially the gloves (rather than by the clothing proper), only the mask, hood, and gloves were worn.

Twenty-four subjects (none of whom were subjects in the main experiment) were randomly divided into two groups of 12 men each. One group wore the protective items while the other was unprotected. Both groups then performed the Rifle Loading and Unloading Test, and then the Rifle Disassembly and Assembly Test. Following this, the groups again performed these tests but with conditions reversed, the originally unprotected group now wearing the mask, hood, and gloves while the group initially wearing these items went unprotected.

(U) Dugway Proving Ground Experiment

The experimental design used at Dugway Proving Ground is shown in Figure 2. Forty-five soldiers from a Smoke Generator Company were randomly assigned to three groups of 15 men each.

On each of the three days of testing in the first week, every man took the Carbine Test, the Rifle Bore Cleaning Test, and the Spark Plug Changing Test while in normal uniform, masked, or fully protected, as specified in the design for his group for that day. Each test required about 10 minutes per man.

¹On the advice of the attending medical officer, adjustments were made in assignments so that three men who had worn the complete protective outfit and had suffered heat exhaustion during the first week could serve in the normal clothing condition in the second week. The groups were therefore not completely random during the second week of the Fort McClellan study.

During the second week, every man (except one who had incurred a broken arm between test trials) took the Voice Commands Test and the Radio Test on each of three days, again under the experimental conditions indicated by the design.

**Dugway Proving Ground Experiment
to Evaluate the Effects of CBR Protection
on Troop Performance in Hot Weather**

Date	Task	Troops Involved		
		15 Men	15 Men	15 Men
28 Jul	Each day men took the Carbine Test, the Rifle Bore Cleaning Test, and the Spark Plug Changing Test (One hour per day in respective experimental conditions)	Permeable Protective Outfit	Mask	Normal Uniform
29 Jul		Normal Uniform	Permeable Protective Outfit	Mask
30 Jul		Mask	Normal Uniform	Permeable Protective Outfit
4 Aug	Each day men took the Voice Commands Test and the Radio Test (One hour per day in respective experimental conditions)	Permeable Protective Outfit	Mask	Normal Uniform
5 Aug		Normal Uniform	Permeable Protective Outfit	Mask
6 Aug		Mask	Normal Uniform	Permeable Protective Outfit
17 Aug	Men took the Road March Test and then remained for 22 consecutive hours in their respective experimental conditions	Permeable Protective Outfit	Normal Uniform	Mask

Figure 2 (U)

Because support could not be made available, no research was conducted during the third week. On 17 August, however, the soldiers took the Road March Test, and then remained in their respective clothing conditions for 22 consecutive hours (with short periodic breaks, as at Fort McClellan). On subsequent days the weather was so cool (around 70° F.) that it was impossible to conduct the tests under the hot weather conditions required. Accordingly, no further data were collected.

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(U) Weather and Climate

The temperatures at Fort McClellan and Dugway Proving Ground were high during the periods of data collection, the dry-bulb readings averaging about 90°F. at each location. At Fort McClellan the relative humidity averaged around 50 per cent, ranging from 40 per cent to 72 per cent; at Dugway it averaged around 20 per cent, ranging from 10 per cent to 29 per cent.

There was no rainfall at either location during the collection of the data. Meteorological readings, including wind speed and sky cover, for the approximate hours of testing are listed in Appendix A.

(C) RESULTS AND DISCUSSION

Heat Exhaustion

On two occasions, wearing the mask or the permeable protective outfit was associated with heat injury to some of the troops involved. On 29 June at Fort McClellan, during or immediately after Trial 2 of the Smoke Generator Test, the attending medical officer diagnosed heat exhaustion in three of the masked troops (12%) and 13 of the troops in the permeable protective outfit (40%). These men dropped out of the scheduled activities for some period of time. Four of those from the full-protection group were hospitalized overnight before release to duty. None of the men in normal clothing (the control group) had heat injury or dropped out. Expressed in terms of the proportion of individuals who remained operational (not heat exhausted), the results are 88 per cent operational in the masked group and 60 per cent operational in the fully protected group (see Figure 3).

During the five-mile, two-hour Road March Test the following day, one of the masked soldiers (4%) and 10 of the protectively uniformed men (31%) dropped out with heat exhaustion (leaving 96% and 69% operational, respectively); again, none of the control group dropped out or incurred heat injury. Five of the men who dropped out of the protectively uniformed group were men who had dropped out during the previous day on the Smoke Generator Test.

These heat exhaustion figures are probably underestimates of the casualties that would have occurred if no considerations of troop safety had been involved. Had a 25-mile march or a long, uphill assault been required, the dropout rate would probably have been much higher and might have included a number of fatalities. The study was necessarily conducted so as to measure ill effects while at the same time taking steps to reduce the occurrence of ill effects.¹

¹A condensation of the report prepared by personnel of the Directorate of Medical Research of the U.S. Army Chemical Warfare Laboratories bearing on the physiological and medical aspects of this study is presented as Appendix B, "Medical Casualties From Heat Exhaustion and Other Observations (U)," in *Troop Test of CBR Defensive Means (U) (JACKPOT)*, Combat Development Project Report CMLCD 57T1, U.S. Army Chemical Corps, Army Chemical Center, Md., June 1960 (CONFIDENTIAL).

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Percentages of Men Remaining Operationally Effective (Not Heat Exhausted) After Two Tests at Fort McClellan

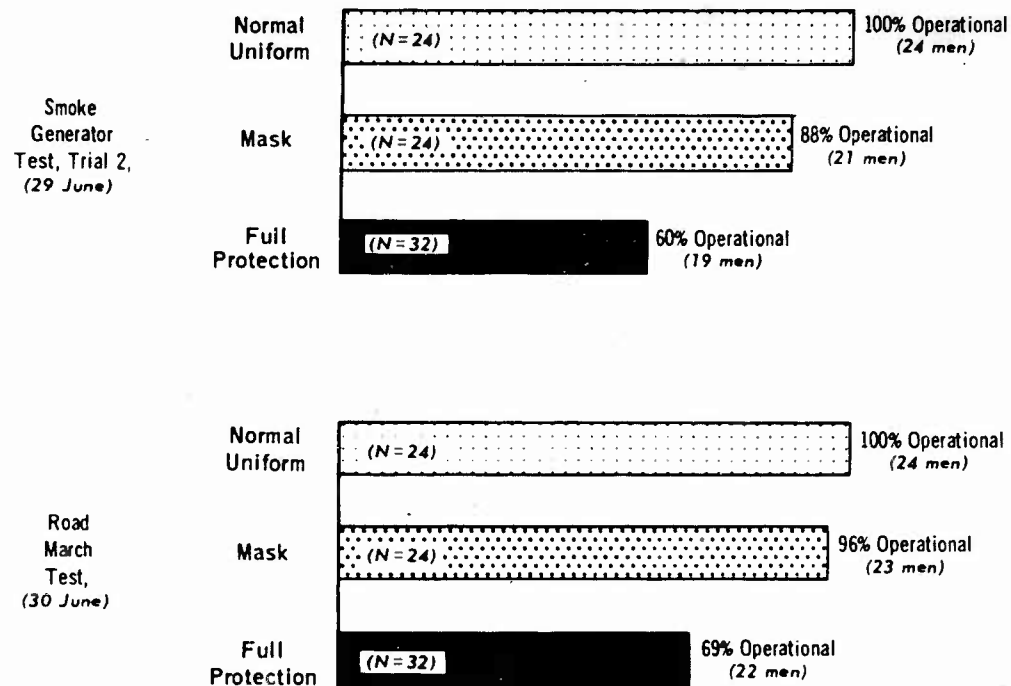


Figure 3 (C)

In contrast with the number of heat exhaustion cases during the first week, however, results of tests conducted the following week indicated that such strenuous activities can sometimes be performed during hot weather with little or no occurrence of heat exhaustion. During the last week of the Fort McClellan experiment, in addition to performing the Running Test the troops repeated the Smoke Generator Test and the five-mile, two-hour Road March Test. the two tests during which so many heat exhaustion dropouts had occurred the previous week. This time only three men dropped out with heat exhaustion, two of whom dropped out twice; of these five dropouts, three occurred in the fully protected condition and two in the normal condition. Also during the last week at Fort McClellan, the troops (except for the dropouts mentioned) remained in their respective experimental conditions, with occasional short unmasked breaks, for three consecutive days and nights (81 hours), including sleeping in the assigned experimental conditions.

Similarly, at Dugway Proving Ground, the four-mile Road March Test was successfully completed by all troops except for one dropout in the fully protected group (a reputed malcontent with no evidence of heat exhaustion); the men then remained (and, at night, slept) in their respective experimental conditions for 22 hours. The experiment was terminated when the temperature became too cool to constitute a challenge.

Mean Time to Perform Smoke Generator Test
(Trial 1)

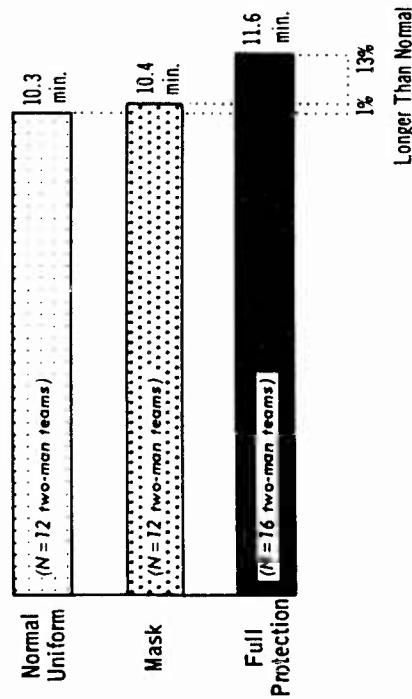


Figure 4 (C)

Mean Time to Perform Rifle Loading Test

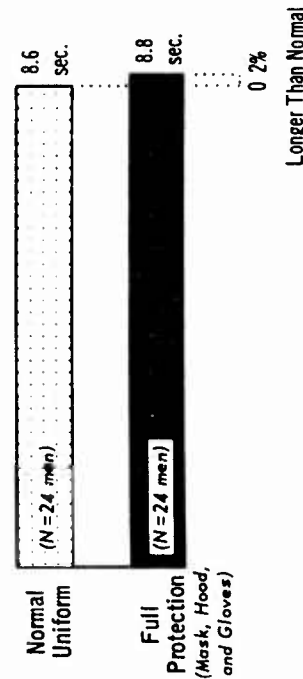


Figure 6 (U)

Mean Time to Perform Running Test

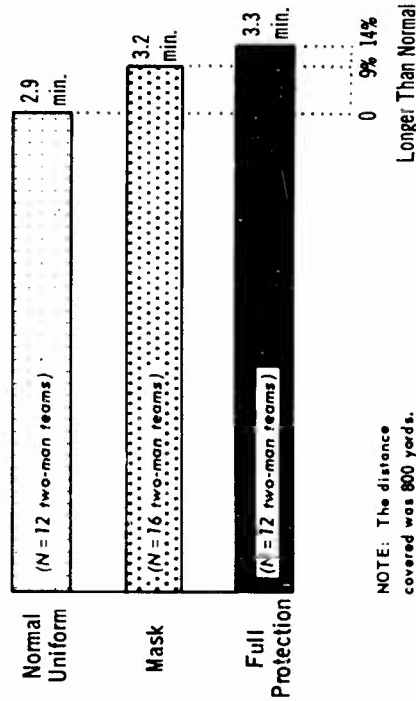


Figure 5 (C)

Mean Time to Perform Rifle Unloading Test

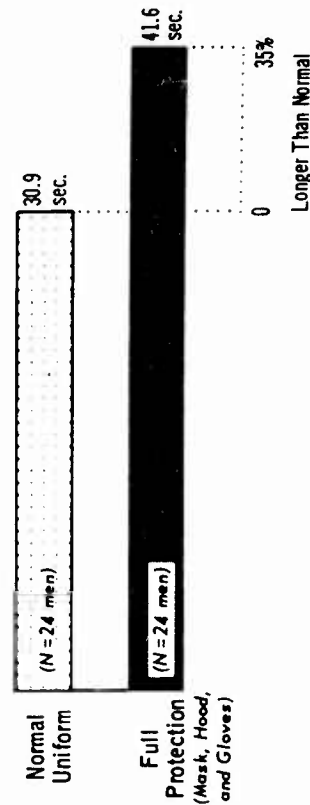


Figure 7 (U)

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Why the first and second weeks at Fort McClellan differed so drastically in numbers of heat-exhaustion dropouts is not known. Inspection of the meteorological data in Appendix A and of the daily schedule of test activities provides no convincing explanation of this fluctuation in dropout rate. The numerous dropouts occurring in the first week indicate that there is a danger of heat injury to CBR-protected troops in hot weather operations; however, the much smaller incidence of heat exhaustion in the second week indicates that, in spite of this danger, considerable physical work can sometimes be carried out under such conditions with little or no ill effect on men's health.

Impairment in Performance

The average extent to which the mask and the protective outfit slowed or impaired performance on each activity (except for the Road March Test discussed in the preceding section) is shown in Figures 4 through 16. Distributions of test scores, showing the overlap in proficiency among the normally clothed, masked, and fully protected groups, are presented in Appendices B through D.

On all comparisons the masked subjects were inferior in performance to those in normal uniform. Further, in every test comparison except one (the Voice Commands Test at the 90-yard range), performance in the fully protected condition was inferior to that in the masked condition.

On Trial 1 of the Smoke Generator Test the masked group required, on the average, one per cent more time to perform the task, and the fully protected group required 13 per cent more time than did the normally clothed group (Figures 4 and B-1). Notice that Trial 1 and Trial 2 of this task differed dramatically in their effects on the fully protected group (Figures 3 and 4). On the first trial the fully protected men were merely slowed down a little; but, within the next 20 minutes, as they continued their strenuous activity in the second trial, 40 per cent of them were out of action with heat exhaustion. This indicates the fallacy in thinking that because troops are showing no signs of trouble there is "nothing to worry about." Actually, large numbers of them may be on the verge of heat exhaustion.

The strenuous 800-yard Running Test was performed by the masked troops in 9 per cent more time, and by the fully protected men in 14 per cent more time, than was required by the normally clothed men (Figures 5 and B-2).

The results on the Rifle Loading and Unloading Test (Figures 6, 7, C-1, and C-2) and the Rifle Disassembly and Assembly Test (Figures 8, 9, C-3, and C-4) suggest that the gloves of the permeable protective outfit interfere only slightly in the grosser manipulations used in loading or disassembling the rifle (decrements of 2% and 5%), but interfere much more with the especially complex finger-dexterity skills involved in unloading the rifle or in assembling the weapon (decrements of 35% and 44%). These latter actions required reloading the loose ammunition into the clip after clip ejection, and the intricate reassembly of the small parts of the trigger-housing group.

18 Mean Time to Perform Rifle Disassembly Test

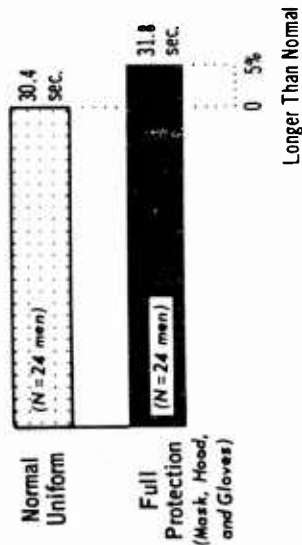


Figure 8 (U)

Mean Time to Perform Rifle Bore Cleaning Test

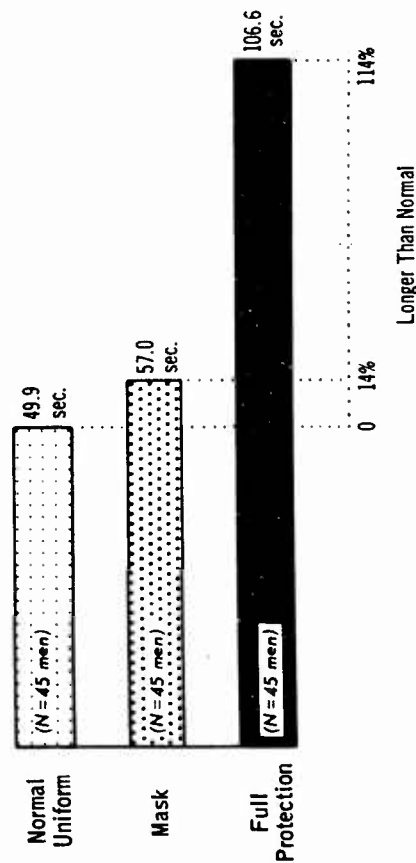


Figure 10 (U)

Mean Time to Perform Rifle Assembly Test

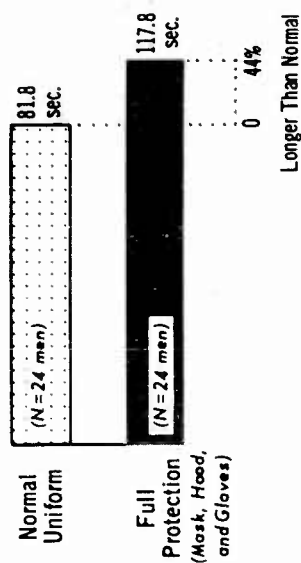


Figure 9 (U)

Mean Time to Perform Spark Plug Changing Test

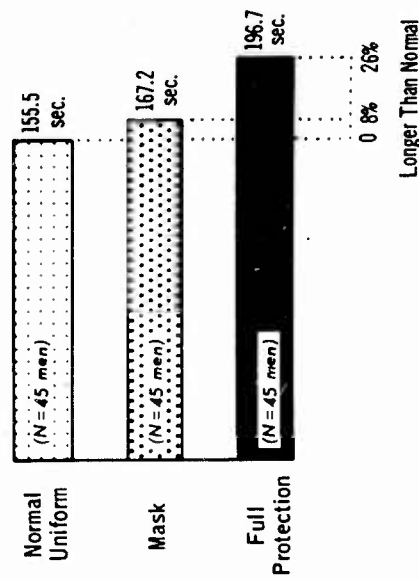


Figure 11 (U)

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In the Rifle Bore Cleaning Test (Figures 10 and D-1) an extremely large difference was revealed between the amount of impairment due to the mask and the decrement due to the permeable protective outfit; in fact, soldiers under the fully protected condition took more than twice as long (114% more time) to do the task than did soldiers normally clothed. It was apparent in observing the soldiers performing this task that the gloves worn by the men in the permeable protective outfit made it much more difficult to fold the cloth patch and insert it through the slot in the patch holder.

On the Spark Plug Changing Test, the masked men required 8 per cent more time, and those fully protected required 26 per cent more time, than that taken by the men in normal uniform (Figures 11 and D-2).

The results on the Carbine Firing Test show that 12 per cent more than the normal time was required in the masked condition, and 25 per cent more in the fully protected condition; it should be noted, however, that these percentages indicate a difference of only a fraction of a second between the normal and the masked conditions, and between the normal and the fully protected conditions (Figures 12 and D-3). When "hits" were used as a measure, the masked group scored 12 per cent fewer hits, and the fully protected group 23 per cent fewer hits, than the men in normal uniform, who averaged about six hits out of the total possible score of 10 (Figures 13 and D-4).

The results of the Radio Test show that, for either type of protection, greater decrements in communication occurred with the plain-language commands than with the phonetic alphabet (Figures 14, 15, D-5, and D-6).

On the Voice Commands Test, performance of the troops in the protective equipment was much poorer than that of the normally uniformed troops at the shortest range tested (30 yards), and this difference increased sharply as range increased, even though performance of the normal group also was sharply impaired as range increased (Figures 16 and D-7). Except for the slight inversion at the 90-yard range, the fully protected condition—specifically because of the hood, which covers the ears—interfered with communication even more than did the mask alone.

Where comparisons could be made on similar tests, decrements due to masking, as measured by the various tests in the present study, were of the same general size as those found in the previous masking study.¹ Only the decrements on the Voice Commands Test differed drastically over the two occasions, the decrements for the masked condition in the present study being two or three times larger than those reported previously, amounting to increases of 28 to 54 percentage points. The cause of this difference in results is not known.

Suggestions as to other types of impairment in military performance that may result from wearing the protective equipment were indicated in interviews conducted with some of the officers and men who wore the permeable protective outfit at Fort McClellan either as subjects or as troop leaders. One lieutenant reported that the equipment slowed his

¹HumRRO Technical Report 57, *op. cit.*

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Mean Time per Round
to Perform Carbine Firing Test

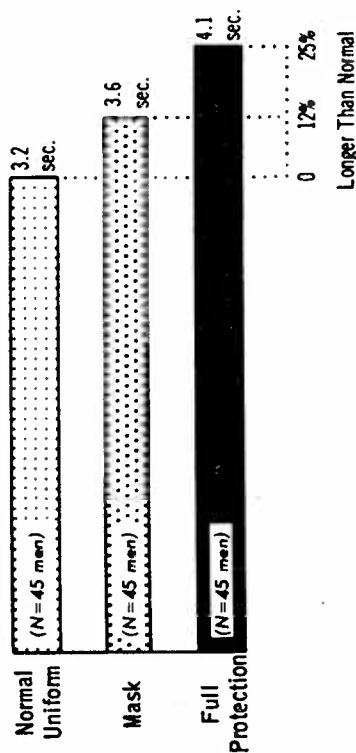


Figure 12 (C)

Mean Number of Hits
on Carbine Firing Test

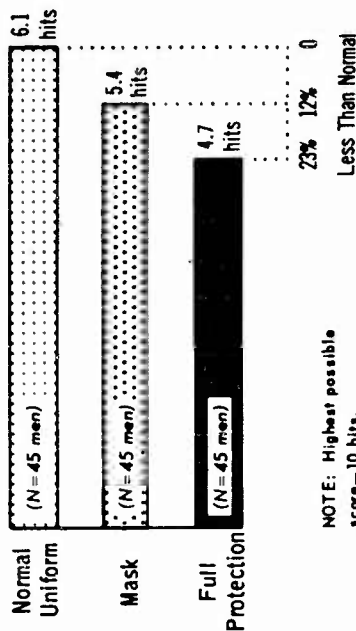


Figure 13 (C)

Mean Number of Phonetic Alphabet Messages
Correctly Received on Radio Test

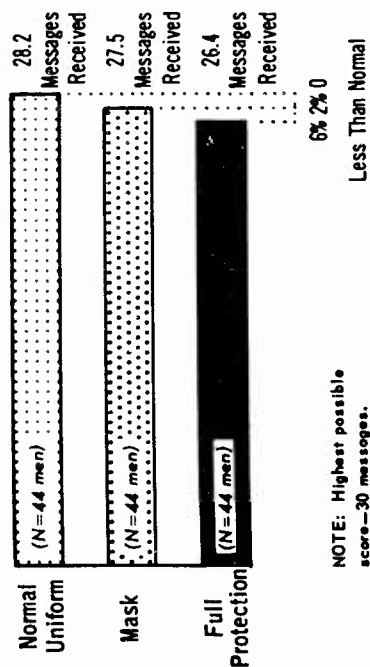


Figure 14 (C)

Mean Number of Plain-Language Messages
Correctly Received on Radio Test

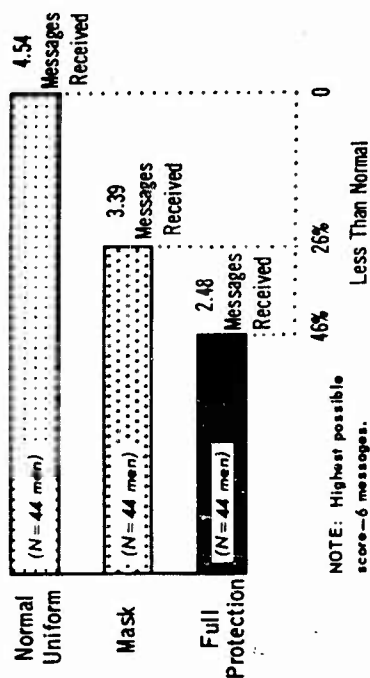


Figure 15 (C)

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Mean Number of Messages Correctly Received on Voice Commands Test

NOTE: Highest possible score at each range—2 messages. The N was 44 men in each of the three experimental conditions.

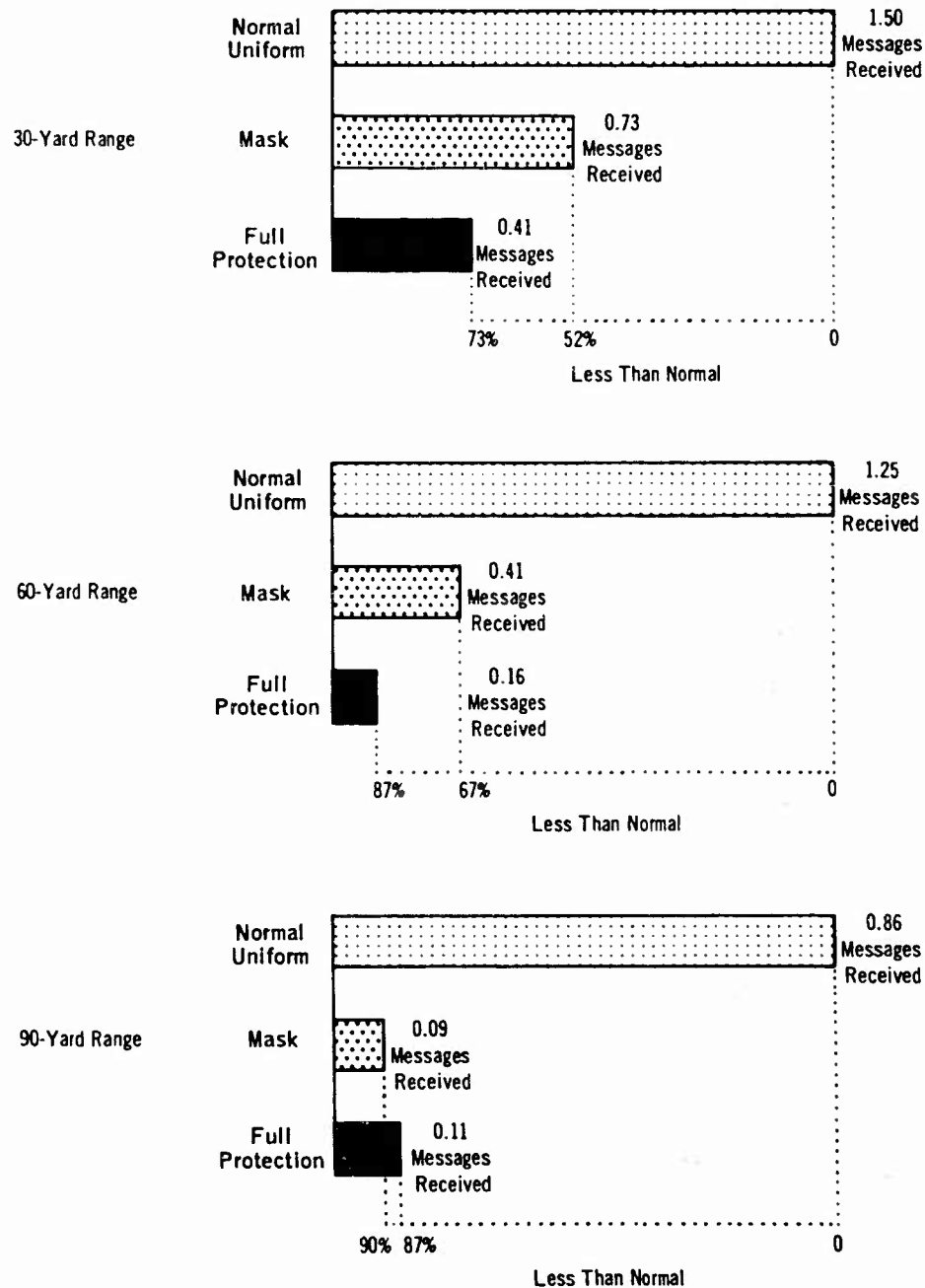


Figure 16 (C)

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reactions to new situations, that he had to resist a tendency to let others attend to matters he ordinarily took care of, and that during the road march the equipment kept him from following his usual practice of moving up and down the column checking his NCO's and men. Another lieutenant reported that he had continued to carry out his duties during the study in spite of pains in his stomach and heat rash on the lower part of his body. A corporal reported that he had continued to participate in spite of feeling nauseated, out of breath, and "as though in a closed room." One Pfc reported that he had experienced a pain in his head before suddenly falling unconscious while lifting a barrel of fog oil. Such accounts as these indicate that wearing the protective equipment can cause discomfort, which would probably tend to prevent men from maintaining as high a quality of performance as they otherwise would.

APPENDICES

Appendix A (U)

METEOROLOGICAL INFORMATION

The dry-bulb temperature, wet-bulb temperature, relative humidity, wind speed, and sky cover for the day and approximate hour of each of the tests is given below. The readings for Fort McClellan were taken at Anniston Airport (about five miles distant) except for the wet-bulb figures, which are U.S. Weather Bureau readings taken at Birmingham Municipal Airport. All Dugway Proving Ground readings were taken directly at the site of testing.

Fort McClellan, Alabama, 1959

Date	Hour	Test	Temperature		Relative Humidity (%)	Wind Speed (MPH)	Sky Cover (Tenths)
			Dry-Bulb (°F.)	Wet-Bulb (°F.)			
29 Jun	1200	Smoke Generator	93	74	43	3	7
30 Jun	0800	Road March	83	75	72	2	0
1 Jul	1200	Rifle Loading and Unloading					
		Rifle Disassembly and Assembly	92	78	49	9	8
7 Jul	1200	Smoke Generator	92	74	42	9	4
8 Jul	1200	Road March	87	72	52	14	8
		Smoke Generator					
9 Jul	1200	Running	91	71	40	3	7
		Smoke Generator					

Dugway Proving Ground, Utah, 1959

28 Jul	1400	Carbine					
		Spark Plug Changing	94	58	10	--	0
		Rifle Bore Cleaning					
29 Jul	1400	Carbine					
		Spark Plug Changing	93	58	10	6	0
		Rifle Bore Cleaning					
30 Jul	1400	Carbine					
		Spark Plug Changing	89	63	25	12	10
		Rifle Bore Cleaning					
4 Aug	1000	Voice Commands	88	64	29	10	6
		Radio					
5 Aug	1000	Voice Commands	85	61	26	7	1
		Radio					
6 Aug	0930	Voice Commands	84	60	25	9	1
		Radio					
17 Aug	1400	Road March	100	61	10	4	3

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Appendix B SCORES ON STRENUOUS TESTS AT FORT McCLELLAN

Scores on Smoke Generator Test (Trial 1)

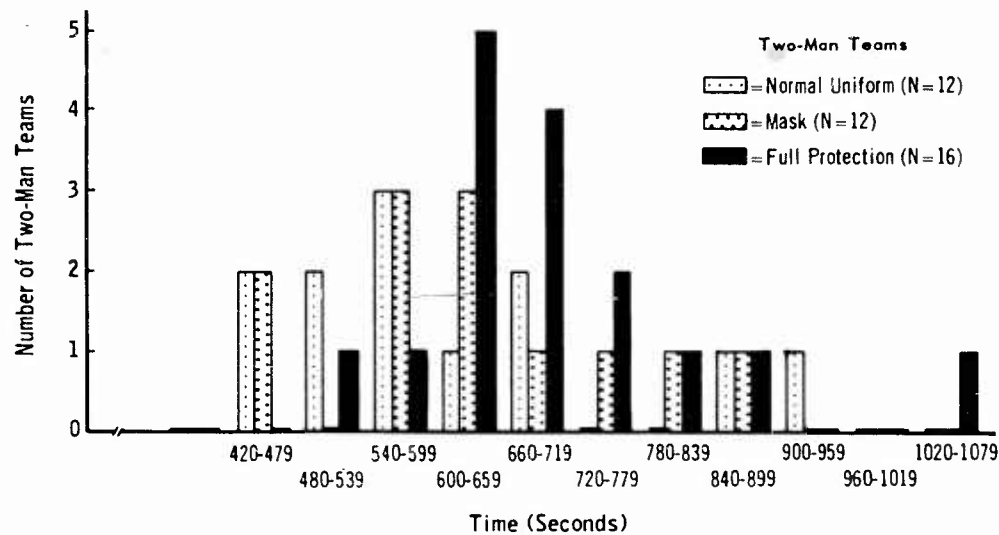


Figure B-1 (C)

Scores on Running Test

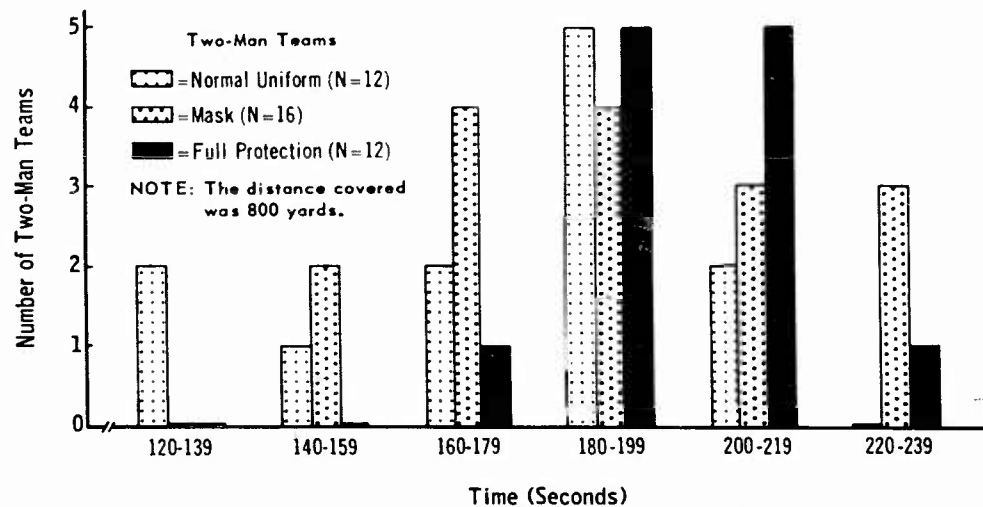


Figure B-2 (C)

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Appendix C SCORES ON MANUAL DEXTERITY TESTS AT FORT McCLELLAN

Scores on Rifle Loading Test

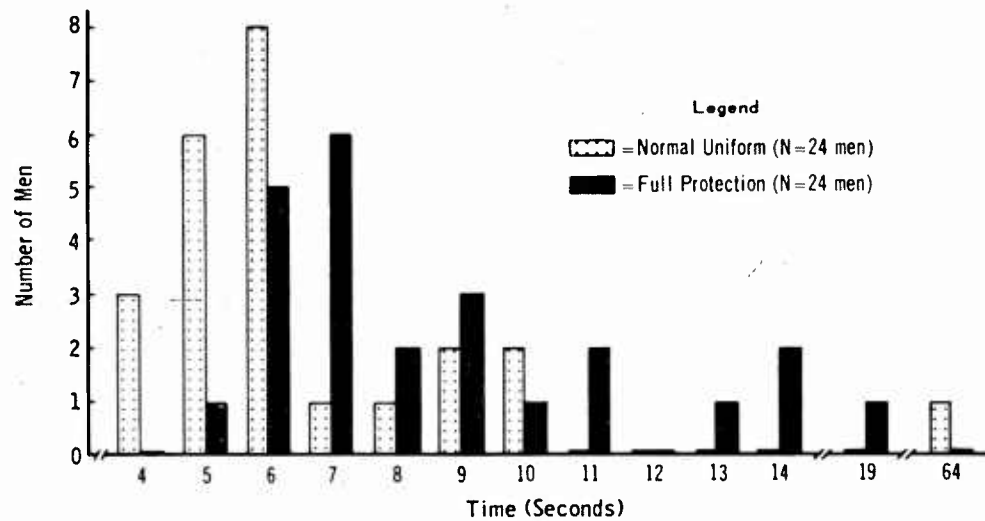


Figure C-1 (C)

Scores on Rifle Unloading Test

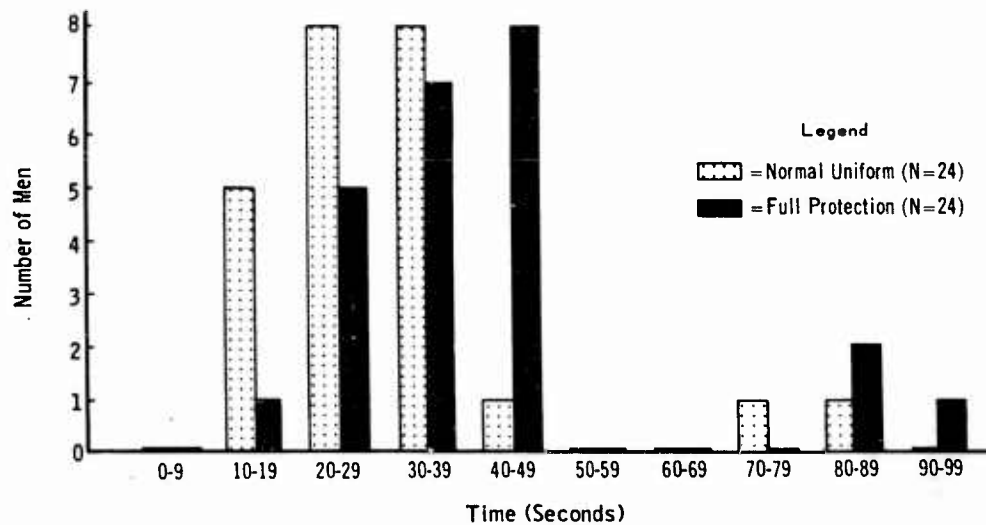


Figure C-2 (C)

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Scores on Rifle Disassembly Test

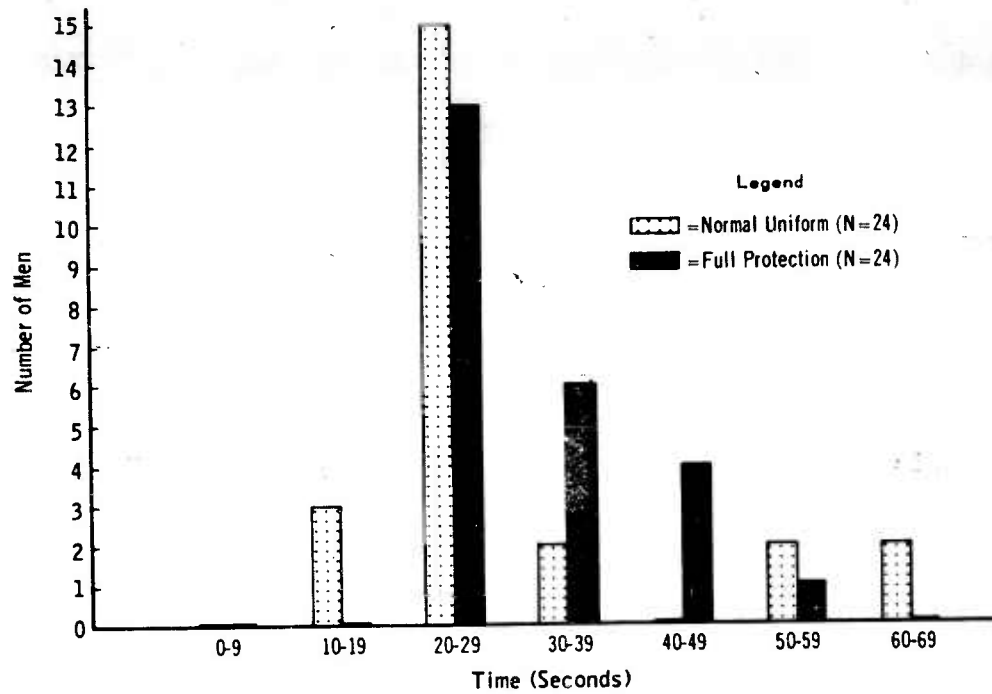


Figure C-3 (C)

Scores on Rifle Assembly Test

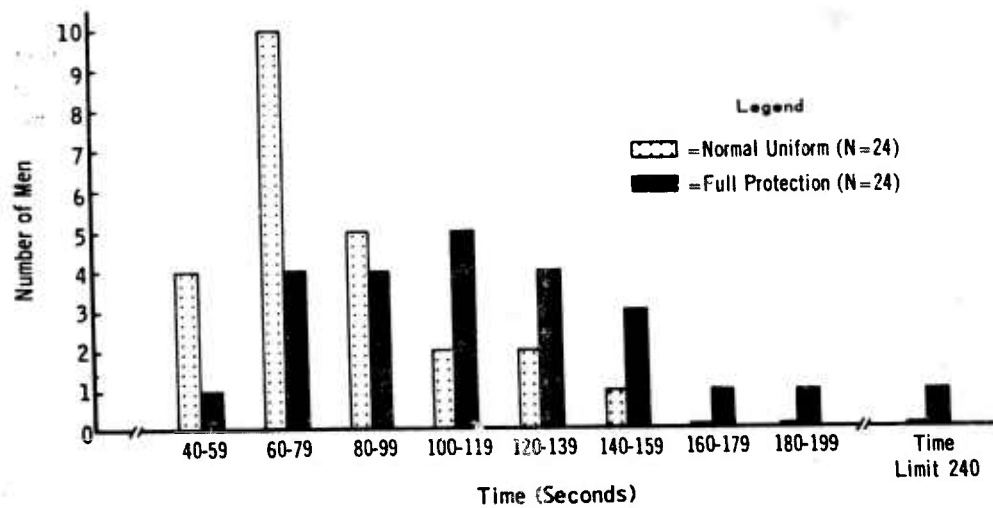


Figure C-4 (C)

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Appendix D

SCORES ON TESTS AT DUGWAY PROVING GROUND

Scores on Rifle Bore Cleaning Test

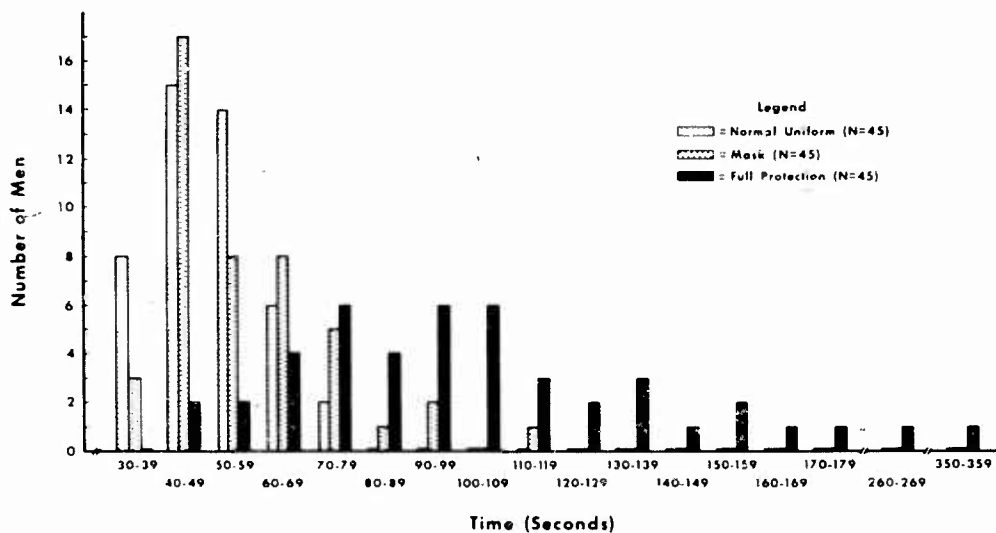


Figure D-1 (C)

Scores on Spark Plug Changing Test

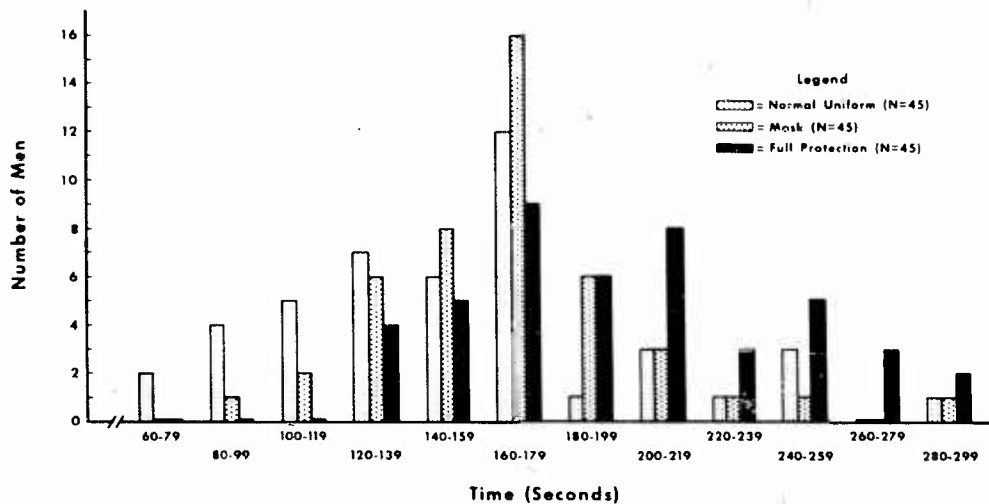


Figure D-2 (C)

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Time Scores on Carbine Firing Test

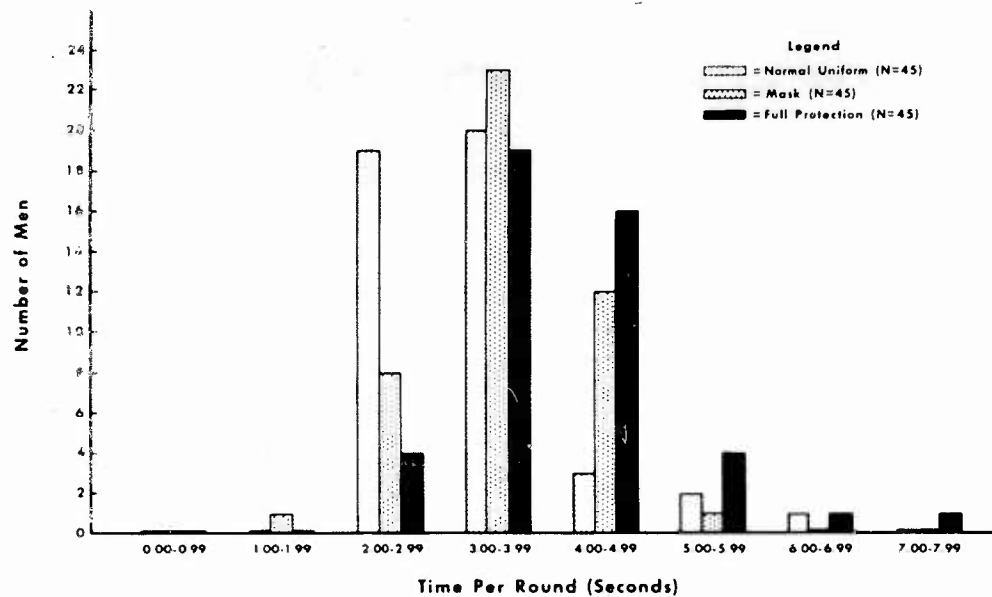


Figure D-3 (C)

Hit Scores on Carbine Firing Test

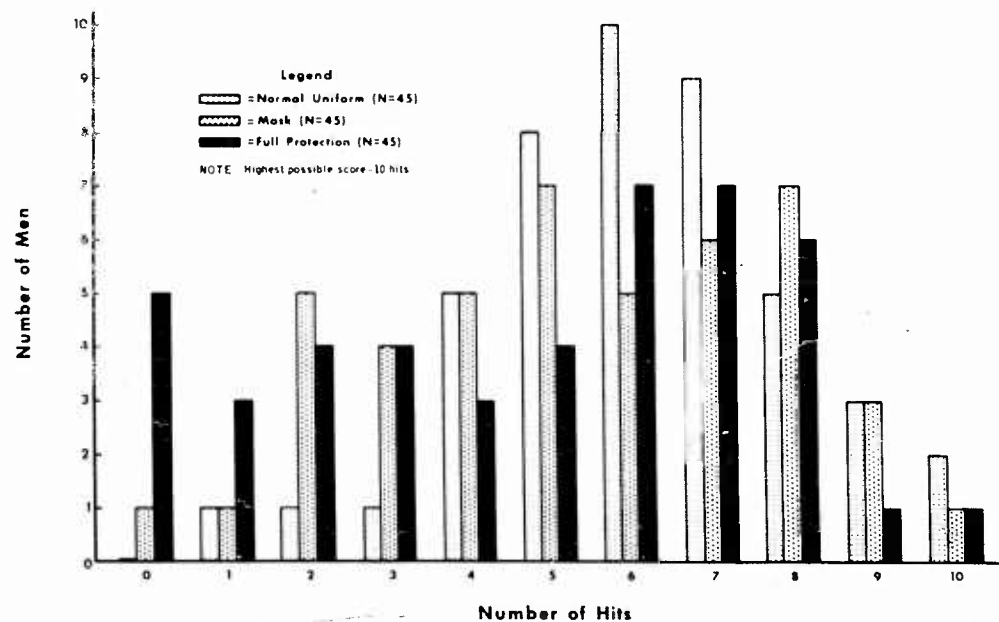


Figure D-4 (C)

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Phonetic Alphabet Message Scores on Radio Test

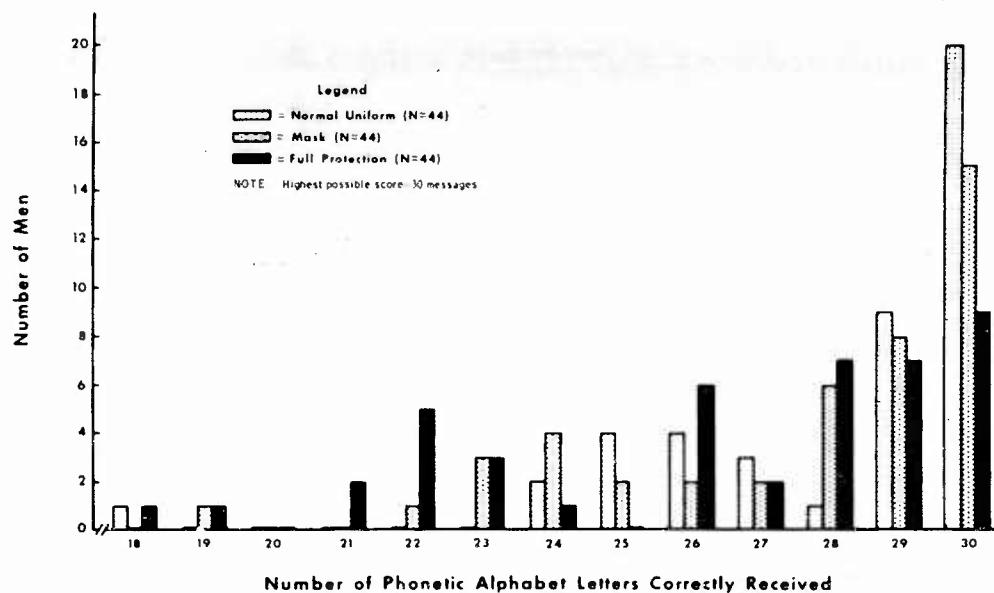


Figure D-5 (C)

Plain-Language Message Scores on Radio Test

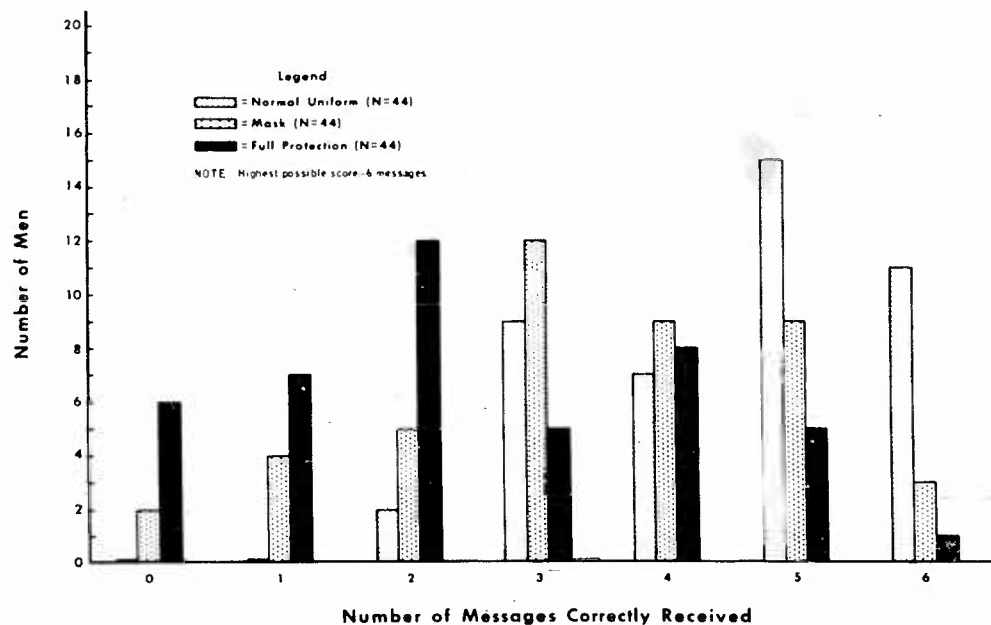


Figure D-6 (C)

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Scores on Voice Commands Test

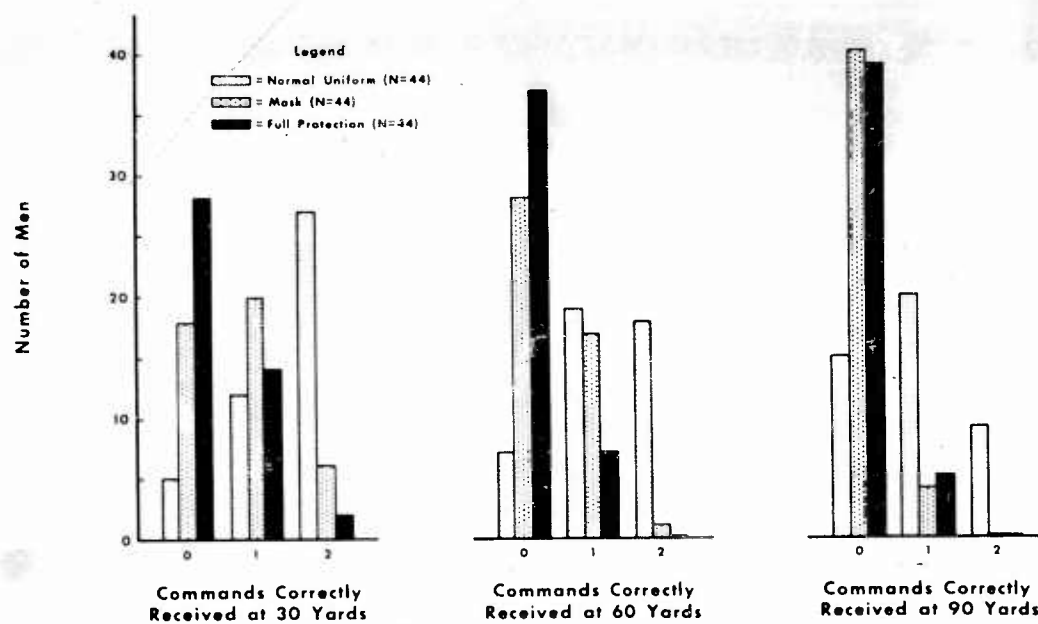


Figure D-7 (C)

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2 TNO METHODS DIV HUMRRO
3 USA ARMOR HUMAN RES UNIT HUMRRO FT KNOX
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5 USA INFANTRY HUMAN RES UNIT HUMRRO
FT BENNING
5 USA AIR DEFENSE HUMAN RES UNIT HUMRRO
FT BLISS
2 USA AVIATION HUMAN RES UNIT HUMRRO
FT HUCKER
10 HQ USCONARC FT MONROE ATTN CHF RES BR
TNO DIV DCS OPNS PLANS TNO
1 CHF RES & DEVEL DA
ATTN SCIENTIFIC INFO BR RES SPT DIV
1 CHF DEFENSE ATOMIC SPT AGY
1 DIR WEAPONS SYSTEMS EVAL GR
1 CDR FLD COMD DEFENSE ATOMIC SPT AGY
SANDIA BASE ALBUQUERQUE
1 CINC US ARMY PACIFIC APO 938 SAN FRAN
ATTN G3 O&T DIV
2 CO SOUTH EUROPEAN TASK FORCE APO 146 NY
3 CO US ARMY JAPAN APO 343
SAN FRAN ATTN G3
1 CO US ARMY CANIBELAN APO 834 NEW ORLEANS
1 CO US ARMY ALASKA APO 949 SEATTLE
ATTN COMBAT DEVEL
2 CO US ARMY EUROPE APO 403 NY
ATTN OPNS DIV
1 CO USA TRANS RES COMD FT KUSTIS
ATTN CHF RES HEP CTR
6 CO SECOND ARMY FT BEL O MEADE ATTN G3
1 CO THIRD ARMY FT MC PHERSON
1 CO FOURTH ARMY FT SAN HOUSTON ATTN G3
1 CO FIFTH ARMY CHICAGO ATTN G3
1 CO SIXTH ARMY FREN OF SAN FRAN ATTN G3
1 CO SEVENTH ARMY APO 46 NY ATTN G3
1 CO EIGHTH ARMY APO 301 SAN FRAN
2 CO TENTH ARMY APO 301 SAN FRAN ATTN G3
1 DIR HUMAN ENGIN LABS
ABERDEEN PROV GND MD
1 CO ORD TNO COMD ABERDEEN PROV GND MD
ATTN CURRICULUM BR
2 PSYCHOL BR ENVIRONMENTAL RES DIV
USA QM RES & ENGIN CTR NATICK MASS
2 CO USA QM RES & ENGIN CTR NATICK MASS
ATTN TECH LIB
3 DIR CHEM WARFARE LABS USA CHEM CTR MD
ATTN TECH LIB
1 PRES USA CHEM CORPS RD USA CHEM CTR MD
CO CHEM CORPS FLD REQS AGY FT MCCLELLAN
1 CO ARMY BALLISTIC MISSILE AGY
REDBSTONE ARSENAL ATTN ORDHS MI
12 CO FIRST GUIDED MISSILE BRIG FT BLISS
1 CHF DEPT CLIN & SOC PSYCHOL WALTER REED
ARMY INST RES WALTER REED ARMY MED CTR
2 ACS G3 USA SIG TNO CTR FT GORDON
ATTN CHF PLANS & REQS BR
2 CO FT ORD
1 CO DUGWAY PROV GND DUGWAY UTAH
ATTN TECH LIB
1 DIR WALTER REED ARMY INST RES
WALTER REED ARMY MED CTR
1 DIR WALTER REED ARMY INST RES WALTER
REED ARMY MED CTR NEUROPSYCHIAT DIV
1 CO HQ USA ENLISTED EVAL CTR
FT BENJ HARRISON
1 USA ORD MISSILE COMD REDSTONE ARSENAL
ATTN ORDHS MI
1 HUMAN FACTORS OFC ROTH
AIR PROV GND CTR ELGIN TN
1 CO FRANKFORD ARMY ORD ARSENAL
ATTN ORDBA 1734
3 LIB USA WAR COLL CARLISLE BKS PA
3 DIR MIL PSYCHOL & LDRSHIP US MIL ACAD
1 COMDT ARMY SECURITY AGY TNO CTR & SCH
FT DEVENA ATTN TNO PUBS BR
2 COMDT NATL WAR COLL FT LESLEY J MCNAIR
ATTN CLASSIFIED RECORDS BR LIB
1 USA ARMOR SCH FT KNOX ATTN DIR INSTRUCT
1 COMDT USA ARMOR SCH FT KNOX
ATTN WEAPONS DEPT
3 COMDT USA ARMOR SCH FT KNOX
ATTN COMBAT DEVEL GP
1 COMDT USA CHAPLAIN SCH FT SLOCUM
1 COMDT USA CHEM CORPS SCH FT MCCLELLAN
ATTN EDUC ADV
1 CO CHEM CORPS TNO COMD FT MCCLELLAN
1 COMDT USA FINANCE SCH FT BENJ HARRISON
4 COMDT USA ADJ GEN SCH FT BENJ HARRISON
1 COMDT USA INF SCH FT BENNING
ATTN CHF COMBAT DEVEL OFC
1 LIB USA QM SCH FT LEE
1 COMDT USA QM SCH FT LEE ATTN EDUC ADV
1 CO USA TRANS TNO COMD FT KUSTIS
ATTN COMDT USATSCH
1 ASST COMDT PROVOST MARSHAL GEN SCH
FT GORDON
1 CO USA SIG TNO CTR FT GORDON
1 COMDT USA ORD GUIDED MISSILE SCH
REDBSTONE ARSENAL ATTN ORDHS MI RD
1 COMDT USA ORD SCH ABERDEEN PROV GND MD
2 COMDT USA AIR DEFENSE SCH FT BLISS
10 COMDT USA ARTY & MISSILE SCH FT SILL
1 ARMED FORCES STAFF COLL
NAV OPERATING BASE NORFOLK ATTN LIB
1 COMDT USA SIG SCH FT MONMOUTH
1 COMDT USA JUDGE ADVOCATE GEN SCH U VA
6 COMDT USA ENGIN SCH FT BELVOIR
ATTN LIB BR
6 COMDT USA SPEC WARFARE SCH FT BRAGO
1 EDUC CONSULT USA PROVOST MARSHAL GEN SCH
FT GORDON
6 COMDT USA ENGIN SCH FT BELVOIR
1 DCS PERS DA ATTN CHF CAS DIV
2 OACE INTEL DA ATTN CHF COMBAT INTEL
DEVEL DIV
3 DCS MIL OPNS DA ATTN CHF TNO DIV
1 CHF TRANS DA ATTN RES DIV
2 ASST COMLO FOR PLANS & DOCUMENTS
OFC CHF CHEM OFF ATTN CMPLD CD
1 HQ DA OFC CHF CHEM CORPS ATTN DCCML OSA
1 CHF INFO DA ATTN CHF TI DIV
1 OFC CHF ORD RES & DEVEL DIV
1 ATTN ORDTB RES & SPEC PROJ SECT
1 CHF PSYCHOL & NEUROL CONSULT
OFC SURG GEN DA
1 HQ USA MED RES & DEVEL COMD
ATTN NRAPP RES BR
1 CHF PERS RES BR ADJ GEN OFC DA
1 CHF PERS HQT BR RES & DEVEL DIV
ADJ GEN OFC ATTN AGTR A
1 SYSTEMS DEVEL BR ADJ GEN OFC DA
ATTN AGTR M
1 US ARMY COMBAT SURVEILLANCE AGY
OFC CHF SIG OFF
1 ACS RESERVE COMPONENTS DA
10 CDR ARMED SERV TECH INFO AGY
ARLINGTON VA ATTN TPCR
1 CO US ARMY MED RES LAB FT KNOX
1 CO US ARMY COMBAT SURVEILLANCE AGY
CLARENDON VA
1 CHF RES & DEVEL DA ATTN TECH LIAISON OFC
1 PERS & TNO DIV ORDHS OFC CHF ORD DA
2 PRES US ARMY ARMOR BD FT KNOX
2 PRES US ARMY INF DIV FT BENNING
2 PRES US ARMY AIR DEFENSE BD FT BLISS
1 PRES US ARMY MAINT BD FT KNOX
1 PRES US ARMY ORD BD ABERDEEN PROV GND MD
1 PRES US ARMY SIG CORPS BD FT MONMOUTH
1 PRES ADJ GEN BD FT BENJ HARRISON
1 PRES MIL POLICE BD FT GORDON
1 CO CCA 1ST ARMORED DIV FT HOOD
2 CO 4TH ARMORED DIV APO 326 NY
1 CO 4TH ARMORED GP APO 357 NY
1 CO 3D ARMORED CAV REG FT BRAGG MEADE
2 CO 6TH ARMORED CAV REG FT KNOX
1 CO US ARMY ARMOR & ARTY FIRING CTR
FT STEWART ATTN AC OF S G3 TNO OFF
1 1ST ARMORED DIV HQ & HQ CO FT HOOD
1 1ST CAV DIV 3D MED TK BN
40TH ARMOR APO 24 SAN FRAN
1 1ST INF DIV 1ST MED TK BN
68TH ARMOR FT RILEY
1 3D INF DIV 1ST MED TK BN
68TH ARMOR APO 36 NY
1 4TH INF DIV 1ST MED TK BN
34TH ARMOR FT LEWIS
1 7TH INF DIV 2D MED TK BN
1 40TH ARMOR APO 7 SAN FRAN
6 8TH INF DIV 2D MED TK BN
68TH ARMOR APO 34 NY
1 CO CO D 2B HEAVY TK BN
33D ARMOR APO 163 NY
1 CO 3D MED TK BN
68TH ARMOR APO 25 SAN FRAN
6 CO 3D MED TK BN
33D ARMOR US ARMY ARMOR CTR FT KNOX
1 CO 3D MED TK BN
1 CO 35TH ARMOR APO 26 NY ATTN S3
1 CO 3D MED TK BN
37TH ARMOR APO 36 NY
1 CO 4TH MED TK BN 68TH ARMOR FT BRAGO
1 CO CO C RAYTON 68TH ARMOR
US ARMY INF CTR FT BENNING
6 CO 24TH INF DIV 3D MED TK BN 34TH ARMOR
APO 29 NY
2 CO 1ST INF DIV FT RILEY ATTN G3
2 CO 2D INF DIV FT BENNING ATTN G3
1 CO 4TH INF DIV FT LEWIS ATTN G3
1 CO 6TH INF DIV APO 111 NY ATTN G3
1 CO FT CARSON ATTN G3
1 CO HQ US ARMY HAWAII APO 957 SAN FRAN
ATTN G3
3 CO 82D ABN INF DIV FT BRAGG ATTN G3

6 CO 1ST INF BRIG FT BENNING ATTN Q3
 1 CO 1ST BATTLE GP 1ST INF REG US MIL ACAD
 1 CO 1ST BATTLE GP 3D INF REG FT MYER
 1 CO 3D BATTLE GRP 6TH INF REG APO 742 NY
 1 CO 3D BATTLE GRP 6TH INF REG APO 742 NY
 1 CO 1ST BATTLE GRP 9TH INF REG
 APO 937 SEATTLE
 1 CO 3D BATTLE GRP 31ST INF REG FT RUCKER
 1 CO 1ST ARMORED RIFLE BN 46TH INF REG
 APO 29 NY
 1 CO 1ST ARMORED RIFLE BN 46TH INF REG
 APO 29 NY
 4 CO 3D ARMORED RIFLE BN 51ST INF REG
 APO 39 NY
 1 CO 1ST ARMORED RIFLE BN 52D INF
 FT CARSON
 1 ASSOC DIR ARMY ARMY PARTICIP GP
 US NAV TNO DEV CTR FT WASHINGTON LI
 2 CHF AUDIO VIS APPLICATIONS OFC ARMY
 PICTORIAL DIV OFC CHF SIG OFF
 1 TECH DIR R&E DIV OFC QM GEN
 1 US DOCUMENTS OFF OFC US NATL MIL REP
 SHARP APO 33 NY
 1 CHF DOCTRINE & ORG BR Q3 SECT
 QM TNO COMD FT LEE
 1 CO US ARMY LIAISON GP
 PROJ NICH WILLOW RUN LABS MICH
 1 DIR SYSTEMS RES OP ENGIN EXPERIMENT STA
 COLUMBUS
 1 DIR ARMY LIB
 1 CHF MIL HIST DA ATTN GEN REF BR
 1 CINC US PAC FLEET FLEET HQ SAN FRAN
 1 CHF RES DIV BUR MED & SURG
 1 TECH LIR PERS 11B BUR NAV PERS DN
 1 DIR PERS RES DIV BUR NAV PERS DN
 1 BUR YDS & DKS ATTN DIR RES & DEVEL DIV
 3 CHF NAV PERS DN
 1 CO & DIR USN TNO DEV CTR
 FT WASHINGTON LI ATTN LIRN
 1 CHF PSYCHOLOGIST HUMAN ENGIN DEPT
 US NAV TNO DEV CTR FT WASHINGTON LI
 1 CLIN PSYCHOLOGIST MENTAL HYGIENE UNIT
 US NAV ACAD
 1 CHF NAV RES DN ATTN HD PERS & TNO BR
 CODE 430
 1 CHF NAV PERS DN ATTN DIR PSYCHOL SCI DIV
 CODE 430
 1 CHF NAV RES DN ATTN HD OF PSYCHOL BR
 CODE 432
 1 OFF IN CHD US NAV PERS RES FLD ACTIVITY

1 CHF NAV AIR TNO TNO RES DEPT
 NAV AIR STA PENSACOLA
 1 CDR PAC MISSILE RANGE US NAV MISSILE CTR
 PT MUGU CALIF ATTN TECH LIR CODE 210
 1 US NAVY NEUROPSYCHIAT RES UNIT SAN DIEGO
 1 COMDT MARINE CORPS CODE DC
 HQ US MARINE CORPS
 1 COMDT MARINE CORPS
 HQ US MARINE CORPS ATTN AO 4E
 1 DIR MARINE CORPS EDUC CTR MARINE CORPS
 SCHOOLS QUANTICO ATTN ARCH & HIST G
 1 COMDT MARINE CORPS CODE AO 3C
 HQ US MARINE CORPS
 1 DIR MARINE CORPS INST ATTN EVAL UNIT
 1 CHF NAV OPNS OFC OIR
 1 CHF NAV AIR TECH TNO NAV AIR STA MEMPHIS
 2 DIR TNO DCS P HQ US AIR FORCE ATTN PTR P
 1 DEPT AIR FORCE HQ USAF ACS INTEL
 ATTN AFGIN 3 M
 1 CHF HUMAN FACTORS DIV DIRCTE RES &
 TECHNOL DCS DEVEL HQ US AIR FORCE
 1 CHF PLACEMENT & EMPLOY REL DIV DIRCTE
 CIVILIAN PERS DCS P HQ US AIR FORCE
 1 HQ AIR RES & DEVEL COMD RDOBL 3
 ANDREWS AFB
 1 CDR ROME AIR DEVEL CTR GRIFFISS AFB
 ATTN HUMAN ENGIN LAB
 2 HQ WRIGHT AIR DEVEL DIV
 WRIGHT PATTERSON AFB ATTN WWRDET
 4 AIR TNO COMD ATTWS RANDOLPH AFB
 1 CDR AIR PAD COMB WRIGHT PATTERSON AFB
 ATTN CHF OPER TNO SECT TNO PSYCHOL BR
 1 DIR AIR U LIR MAXWELL AFB
 1 SCH OF AVIAT MED BROOKS AFB TEX
 ATTN AEROMED LIR
 1 USAF DLIR US AIR FORCE ACAD
 1 CDR ARCTIC AEROMED LAB APO 731 SEATTLE
 ATTN AALP
 1 HQ LACKLAND MIL TNO CTR
 ATTN DIR OPNS LACKLAND AFB
 3 CENTRAL INTEL AGY ATTN OCR MAIL RM
 1 DEP CHF MGT TNO & TNO DEVEL BR TNO DIV
 FED AVIAT AGY ATTN PT 33
 2 DIR OPNS RES OFC BETHESDA MD ATTN LIR
 1 RAND CORP WASH DC ATTN LIR
 1 DIR RAND CORP SANTA MONICA CALIF
 ATTN LIR
 1 MITRE CORP LEXINGTON MASS ATTN LIR
 3 BRITISH DEFENCE RES STAFF
 3 CANADIAN ARMY STAFF W

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