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PIONEERING RESEARCH DIVISION

Research Study Report

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COMPATIBILITY OF ARMY ARCTIC CLOTHING, FOOTWEAR AND HANDWEAR DURING SIMULATED ARCTIC OPERATIONAL TEST C/ LANCE MISSILE SYSTEM

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ABSTRACT

Members of the crew operated the LANCE system at temperatures down to -65° F. while wearing Army arctic clothing. Generally, the clothing kept the men warm and permitted them to perform their jobs efficiently. However, a small number of definite incompatibilities were observed. Most often they involved system equipment and arctic mittens, either during infrequent operations or during ones which took only a fraction of a minute with anti-contact gloves, after the mittens had been removed. In addition, footwear and body clothing were sometimes involved. Experimental electrically heated glove inserts were used by the Gunner and Remote Theodolite Operator and showed promise for increasing the speed and precision of theodolite operation.

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COMPATIBILITY OF ARMY ARCTIC CLOTHING, FOOTWEAR AND HANDWEAR DURING SIMULATED ARCTIC OPERATIONAL TEST OF LANCE MISSILE SYSTEM

1. Introduction

Members of a crew from the U. S. Army Artillery Board at Fort Sill operated the Lance Missile System during test operations in the Eglin AFB Climatic Hanger, at 0, -25, -40, and -65°F., during December 1964.

The U. S. Army Natick Laboratories (NLABS) participated in the Test at the request of the U. S. Army Missile Command, for four reasons: (1) to furnish crew members with properly fitted standard Army cold weather clothing from the NLABS supply at Eglin AFB, (2) to furnish experimental electrically heated handwear and necessary auxiliary equipment, (3) to evaluate the compatibility of NLABS developed clothing and handwear for use with the system under the test conditions, including designation of specific incompatibilities* and when possible their causes, and (4) to recommend changes for reducing incompatibilities and improving operating effectiveness of the crew. (It should be noted that NLABS were not responsible for conducting a general human factors engineering evaluation of the system.)

2. Method

A complete ensemble of standard Army arctic clothing was fitted to each man in order to eliminate incompatibilities resulting from non-standard or improperly fitted clothing. During the test, each crew member was permitted to wear as many items from the ensemble as he considered appropriate for the conditions.

A NLABS representative observed the behavior of crew members during test operations and supplemented these observations by interviews with crew members and by some measurements of the equipment.

3. Results

a. Utilization of clothing, footwear and conventional handwear.

Both temperature and the wearer's work influenced the choice of clothing. All items of the arctic clothing ensemble were worn by the

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*An incompatibility is a problem in integrating components into a man-clothing-equipment system, in which attributes or characteristics of one or more components, or interferences among them, decrease the total system's combat effectiveness.

Crane Operator at -25, -40, and -65°F., by a few other crew members at -40, and by most of the crew at -65°F. The crew members consistently expressed favorable comments concerning the warmth of the clothing worn, with one exception. The crane operator, who was the least active physically, sometimes became very cold.

Temperature definitely affected the use of handwear. At -25°F. crew members frequently removed their arctic mittens and worked in their anti-contact gloves for relatively long periods of time. At -40°F. the arctic mittens were removed less frequently and for briefer periods of time. At -65°F. the mittens were seldom removed and then only briefly for jobs requiring considerable dexterity. It was apparent that jobs which crew members often did not even try to do with arctic mittens at the higher temperatures were done at lower temperatures relatively easily and effectively with the mittens. Practice in working with the mittens may have resulted in greater skill which contributed to their increased use.

b. Compatibility

A small number of specific incompatibilities were observed, nearly all of which were related to handwear or footwear. The nose cone could not be removed with arctic mittens, and anti-contact gloves were always used. Since this operation took only a fraction of a minute, this was not a serious disadvantage. The hand-wheel-retaining-hook-adjusting-strap became very stiff and was difficult to adjust, particularly with arctic mittens.

The "emergency tools" on each vehicle include an axe, crowbar, shovel, sledge, tow cable, mattock handle, and mattock head. Only the crowbar was used during the test. However, all of them are attached to the outside of the vehicle by means of straps and buckles (Figure 1). After becoming frozen with ice and snow, they were impossible to unfasten with arctic mittens and become very difficult to loosen even with anti-contact gloves. Also, they were very difficult to refasten securely when frozen. It is apparent that more easily operated fastenings should be substituted for arctic use.

On a number of occasions when anti-contact gloves were used, exposure of bare skin at the wrist was observed when the arms were extended forward or upward. It appears that for low temperature use, either the wrist portion of these gloves should be lengthened, or the closure between the glove and sleeve should be improved.

Fig. 1 Side view of Self-propelled Launcher, showing emergency tools and recesses used for climbing into the cab.

All the boxes used for stowing the theodolite and other delicate and precise equipment could be opened, and their contents removed and again stowed in place, using arctic mittens (Figure 2). The tripod also appeared to be completely compatible with arctic mittens (Figure 3). However, tape made of skid-resistant insulating material, applied to the tripod legs at locations where they are frequently grasped, might increase safety and ease of handling.

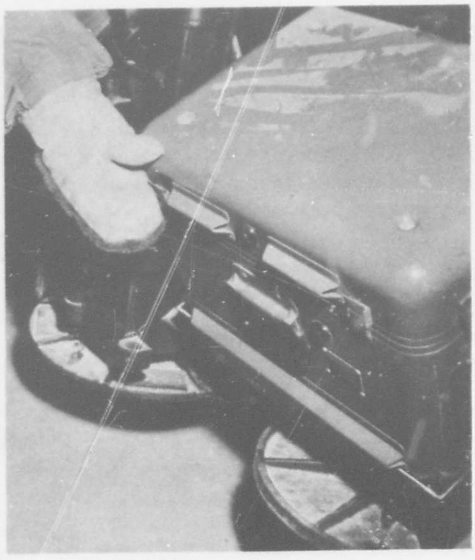

Fig. 2 Opening a box closure with arctic mittens.

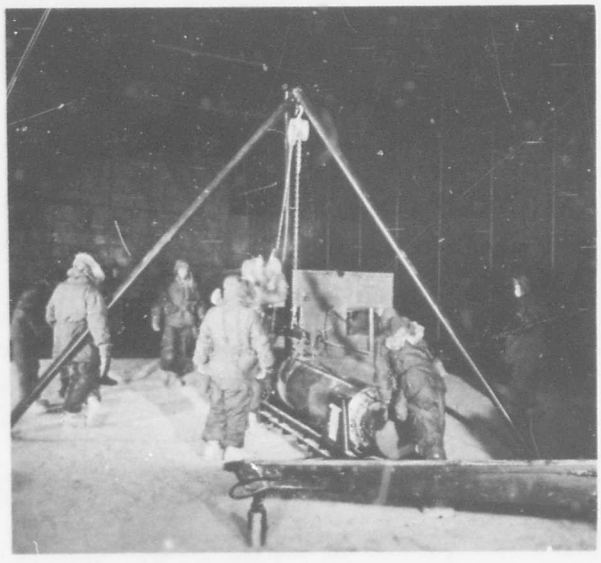

Fig. 3 Tripod Hoist in use.

The crane operator on the Transporter-loader is seated on an expanded metal seat with a back of the same material, and his feet are supported on metal foot rests. He is protected from the wind and cold only by his clothing, and must do critical work continuously for periods of 15 to 30 minutes or longer. For this reason, the seat, seat-back and foot-rests should be well insulated, possibly by plastic foam cushions, for use at sub-zero temperatures.* A "field-fix" foam seat cushion proved to be valuable during the test. However, it is believed that additional insulation for the back of the crane operator's seat and for the foot rests would further increase his efficiency, comfort, and ability to work continuously for long periods.

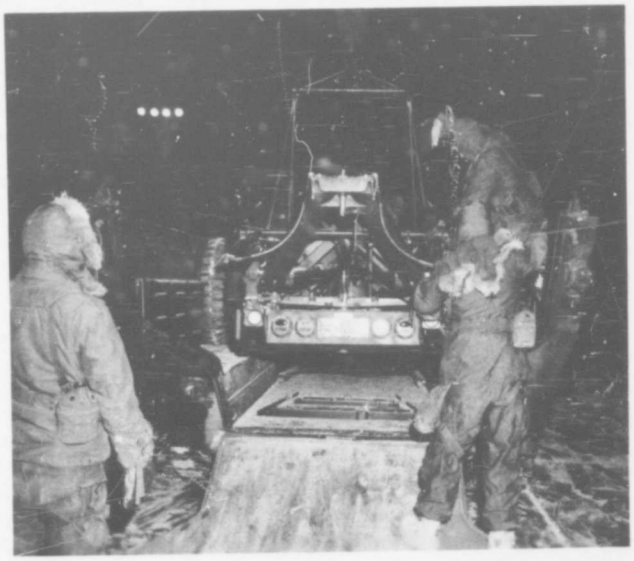

Fig. 4 Rear view of Self-propelled Launcher, showing slippery ramp.

Figure 4 shows the approximately 13^{o} slope of the smooth surfaced ramps located at the rear of the Transporter-loader and of the Self-propelled Launcher. The ramps were very slippery when covered with frost or snow. Even men wearing white arctic insulated

*Some insulation would also appear to be useful at high temperatures, particularly under desert conditions.

boots with cleated soles were frequently observed slipping at this location. For arctic use, a surface is needed which will remain skid-resistant even when frost- or snow-covered. Also, snow sometimes accumulated on the ramps and made them difficult to close until the snow was brushed away. It appears that a good stiff broom would be a useful addition to the arctic equipment of the tracked vehicles.

The openings used for steps when climbing into the driver's compartment of the vehicles are minimal in size and depth for men wearing arctic boots. If feasible, they should be made deeper and sufficiently large for arctic boots of the larger sizes (Figure 1, near the front of the vehicle).

Although not a clothing compatibility problem, it should be noted that the seats for crew members at the sides of the cargo compartment near the rear of the self-propelled launcher are so located that there is no space for the feet when the lightweight launcher is aboard. Also, the ratchet wrenches failed to operate at -65°F., and this fact slowed a number of operations. (It is not known whether arctic lubrication was applied to these tools.)

c. Use of electrically heated glove inserts

The glove inserts which were used with the battery vest kept the theodolite operator's hands warm and furnished adequate dexterity during simulated laying and aiming of the missile. Because there was too much fog for actual sighting at -65°F., a critical test could not be made of the usefulness of the electrically heated gloves in this system. However, the results secured were generally favorable. The gloves kept the hands sufficiently warm to maintain adequate finger dexterity at -65°F., without being too bulky. The fact that no outer shell is now available in the Army supply system which is completely suitable for wear over the heated glove inserts is a disadvantage. Even the "large" size anti-contact gloves are too tight to be worn as shells over the electrically heated inserts by men with large hands. Also, the commonly issued Army five-finger gloves* and most other gloves are too thick and stiff for this purpose. Finally, information is not yet available regarding the durability of the inserts.

Both the Gunner and the Remote Theodolite Operator suggested that only one electrically heated glove for the preferred hand was

*Glove Shells, Leather, Black, M-1959

necessary for operating the Wilde T-16 Theodolites. (Note the position of the left hand in Figure 5). If only one electrically heated glove is used, current requirements and presumably battery weight could be reduced fifty percent. The remote theodolite operator would need to carry a battery, which also could be used to power the light bulb which illuminates the theodolite.

Fig. 5 Operator using one hand to adjust the Remote Theodolite.

The suggestion was also made that one electrically heated glove with thermostatic control would be sufficient for use by the gunner. Moreover, provision could easily be made for connecting it to the missile battery, which provides considerably more power than is actually needed for missile operation. Also the gunner was very active physically, both before and after aiming, and he found the battery vest to be heavy, cumbersome, and a definite handicap.

Specific suggestions were made for improving the design of the battery vest. (1) Being too heavy merely to be hung about the neck, it should be designed like a regular vest. (2) The on-off switch of the battery vest should be located where it can be easily operated without unfastening any clothing, and (3) the weight of the vest should be reduced, even if this requires elimination of auxiliary heat for the less dextrous hand.

In addition, a suggestion was made that the remote theodolite operator's battery vest be replaced by a disposable dry cell battery carried inside his clothing. Such a battery could accompany each missile. A disposable battery would have some logistic advantages over rechargeable batteries which require a strong current source and a bulky and heavy charger. It would be desirable to investigate the availability, shelf-life, weight, and other characteristics of such batteries in relation to the suggested use. Moreover, it is possible that the present battery vest and electrically heated gloves may keep the hands warmer than is necessary for good dexterity, and that the battery capacity could be reduced.

4. Conclusions and recommendations

a. In general, the standard Army arctic clothing protected the men adequately and permitted them to perform their jobs efficiently under the test conditions.

b. Many tasks which had been performed with anti-contact gloves at higher temperatures were done relatively easily with arctic mittens at an ambient temperature of -65°F.

c. If feasible, changes are needed in system equipment to correct incompatibilities which are described in the Results section.

d. There is a need for improvement of wrist closures when anti-contact gloves are worn.

e. The following procedures are recommended for improving the efficiency of theodolite operation at low temperatures:

(1) Furnish gunner an electrically heated glove insert for the skilled hand only, and arrange a convenient attachment for using the missile battery as a power source.

(2) Furnish remote theodolite operator a disposable dry-cell battery to power both an electrically heated glove insert and the light bulb in the theodolite. The battery would be carried and kept warm inside the operator's clothing.