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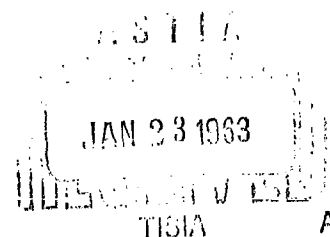
FIELD TESTS OF TWO ANTI-EXPOSURE ASSEMBLIES

Lt. Paul W. Barnett

TECHNICAL DOCUMENTARY REPORT AAL-TDR-61-56

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ARCTIC AEROMEDICAL LABORATORY
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
FORT WAINWRIGHT, ALASKA

Project 8242-2

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ABSTRACT

The purpose of this study was to determine the insulative value of the Navy MK-5 anti-exposure suit and the Air Force CSU4/P partial pressure suit in wet and dry cold environments. Human subjects were exposed to both environments while wearing each assembly. Results of these exposures are shown in graphs of skin and rectal temperatures. A discussion of the results is presented. The MK-5 and CSU4/P assemblies when used with additional protective equipment may be considered adequate protection for dry still air temperatures of -30° F. The MK-5 and liner is adequate protection for water survival in excess of 8 hours. The CSU4/P is adequate water survival protection for periods in excess of two hours. Additional insulation will increase the capability of either assembly during water immersion.

PUBLICATION REVIEW

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FIELD TESTS OF TWO ANTI-EXPOSURE ASSEMBLIES

SECTION 1. INTRODUCTION

Aircrews operating in and from the Alaskan Air Command are frequently required to participate in over water flights and are subjected to water survival in the advent of bailout or ditching. A great amount of research has been done in the area of cold water immersion and protective clothing. Alexander (1946) presented work done by the Luftwaffe during the Second World War in his report on the Dachau experiments. In 1946 Molnar devised a graph of predicted survival times without anti-exposure assemblies. In 1950 Benke and Yaglou performed experiments on nude subjects. Hall and Polte (1955) have done considerable work involving clothed subjects. All of this work has emphasized the need for protection during water immersion even though ambient temperatures may be quite tolerable.

Two types of protection normally employed are the "dry suit" and the "wet suit." The dry suit consists of various types of insulation covered by a vapor impermeable layer. The wet suit is made of material which retains a considerable amount of air and restricts water circulation. This principle has been used in protective clothing of underwater demolition personnel by the U. S. Navy.

The purpose of this study was to determine the thermal characteristics of two anti-exposure assemblies. The extremes of ambient temperatures in the Arctic and subarctic make it necessary that any continuous wear assembly be capable of affording dry cold protection to at least -30° F, since crash or bailout over land is highly probable. Therefore, to test the thermal efficiency of these assemblies for use in the Arctic, it was necessary to perform dry-cold as well as immersion tests.

SECTION 2. METHODS

The two assemblies tested were the Navy MK-5 anti-exposure suit, shown in Figure 1, and the Air Force CSU4/P partial pressure suit, shown in

Figure 2. The MK-5 is a vapor impermeable garment which may be used with various under garments. The CSU4/P while not designed primarily as an anti-exposure suit did appear to have some anti-exposure qualities, the predominant quality being the restriction of water flow around the body. The CSU4/P can be worn with additional over and/or under garments.

Dry Testing

Prior to dry cold exposures subjects donned the thermistor underwear shown in Figure 3 and the applicable anti-exposure assembly in an uncontrolled heated room. Tests were made outdoors with the subjects at two activity levels. During experiments in which the subjects exercised, eight minutes of rest at seven minute intervals were necessary because of the use of an infrared scanning device in conjunction with another study (Veghte and Solli, 1961). Each subject was also exposed for ninety minutes while standing at rest. Temperatures were recorded using Yellow Springs thermistor probes and telethermometers. Eighteen temperature sites (17 skin and 1 rectal) were used. Temperature measurements were recorded five minutes prior to and at ten minute intervals during exposures.

Immersion Testing

Cold water immersions were made at Valdez, Alaska. Subjects donned the thermistor underwear and the applicable anti-exposure assembly in an uncontrolled heated room. The subjects were then driven by ambulance to the water site. Following inflation of the flotation gear, they entered the water using a ladder.(see Figure 4). Temperatures were recorded at five minute intervals for the first hour and at ten minute intervals for the remainder of the test. Exposures were scheduled to terminate after three hours with the MK-5 assembly and after one hour with the CSU4/P assembly. Subjects in the CSU4/P withdrew prior to this time due to intensive pain. Two MK-5 exposures were prematurely terminated due to illness of the subject. (This illness was not associated with the cold exposures.) Temperature measurements were weighed against their representative surface areas and combined to give mean skin temperatures.



FIGURE 1. MK-5 anti-exposure assembly



FIGURE 2. CSU4/P partial pressure assembly



FIGURE 3. Thermistor underwear



FIGURE 4. Subject entering Valdez Bay

SECTION 3. RESULTS AND DISCUSSION

Dry Testing

Using the AAC flying assembly (see Figure 5), which is adequate for -30° F no wind temperatures, as a standard of comparison for the MK-5 and CSU4/P it was possible to determine the temperatures at which these assemblies afforded adequate protection in a dry cold environment. This information is presented in Graphs 1 and 2. Graph 1 shows the skin and rectal temperatures of subjects at rest in all three assemblies. There is no statistically significant difference in skin or rectal temperatures after 90 minutes, but there is a considerable difference in the ambient temperatures at which these tests were performed. Thus, cooling of subjects wearing the CSU4/P and the MK-5 at 19° and 10° respectively is no more acute than subjects wearing the AAC flying assembly at -22° F.

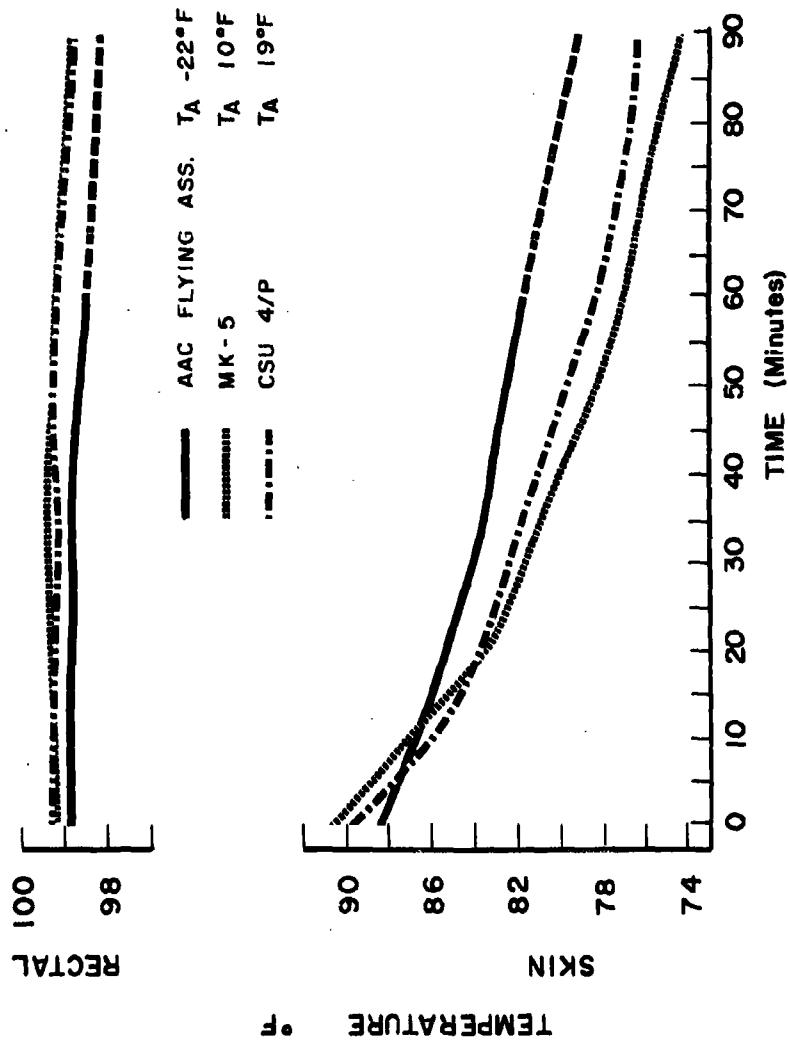
Graph 2 shows the skin and rectal temperatures of subjects in all three assemblies while exercising. The divergence of the curve representing the AAC flying assembly is misleading. The change in ambient temperatures must be noted. While there is no change in exposure temperatures of subjects wearing the AAC flying assembly, there is a significant change in skin temperatures between resting and exercising states. On the other hand, there is no significant change in the skin temperatures of subjects wearing the MK-5 and CSU4/P between activity levels, but there is a significant change between ambient temperatures.

The temperatures at which these assemblies would be adequate dry cold protection are 20° F for the CSU4/P and 10° F for the MK-5. These "use" temperatures could be extended through the use of additional insulation. Although space limitations of modern aircraft restrict the amount of insulation possible, it is within reason to assume the use of the MA 1 flying jacket with hood, pile cap, N2B arctic mittens, CWU1/P flying coveralls or insulated underwear, and the mukluk assembly or thermal boot. With this additional insulation the use temperature of either assembly could be lowered to -30° F. Special emphasis should be placed on the hand and foot gear. Veghte (1961) has shown these areas to be extremely critical.

Other considerations are the heat stress of large amounts of insulation and vapor impermeable materials, and loss of insulative effect due to moisture retention within these materials, discussed by Griffin et al (1944) and Hall (1952).

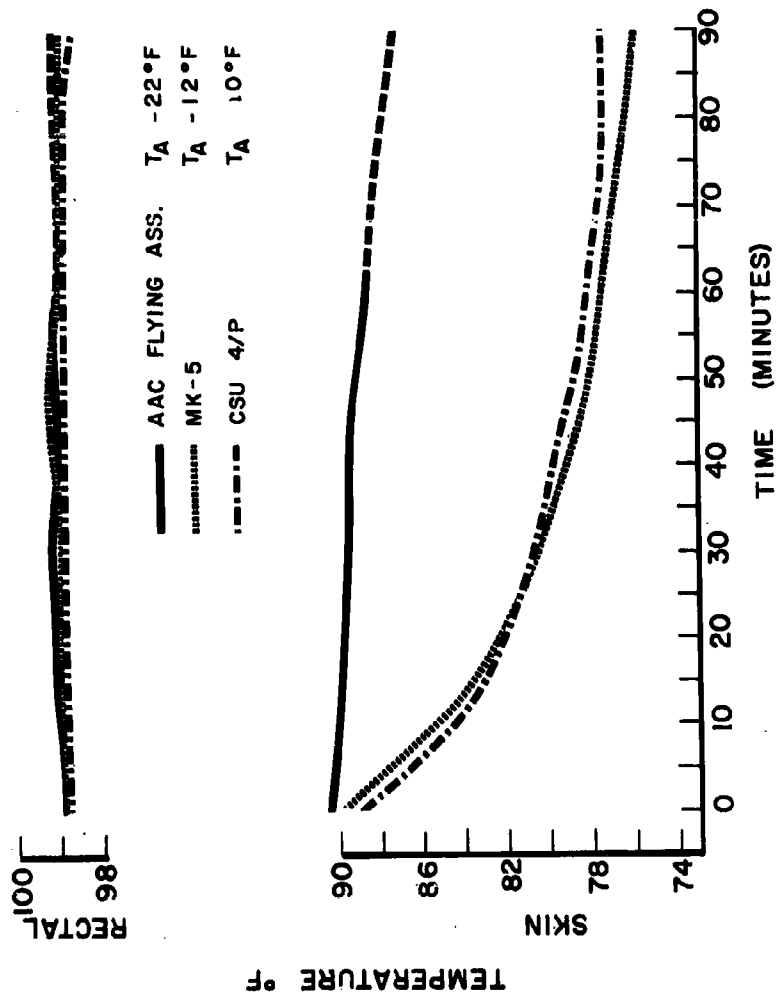


FIGURE 5. AAC flying assembly



GRAPH 1.

Dry cold exposures of all assemblies with subjects at rest



Immersion Testing

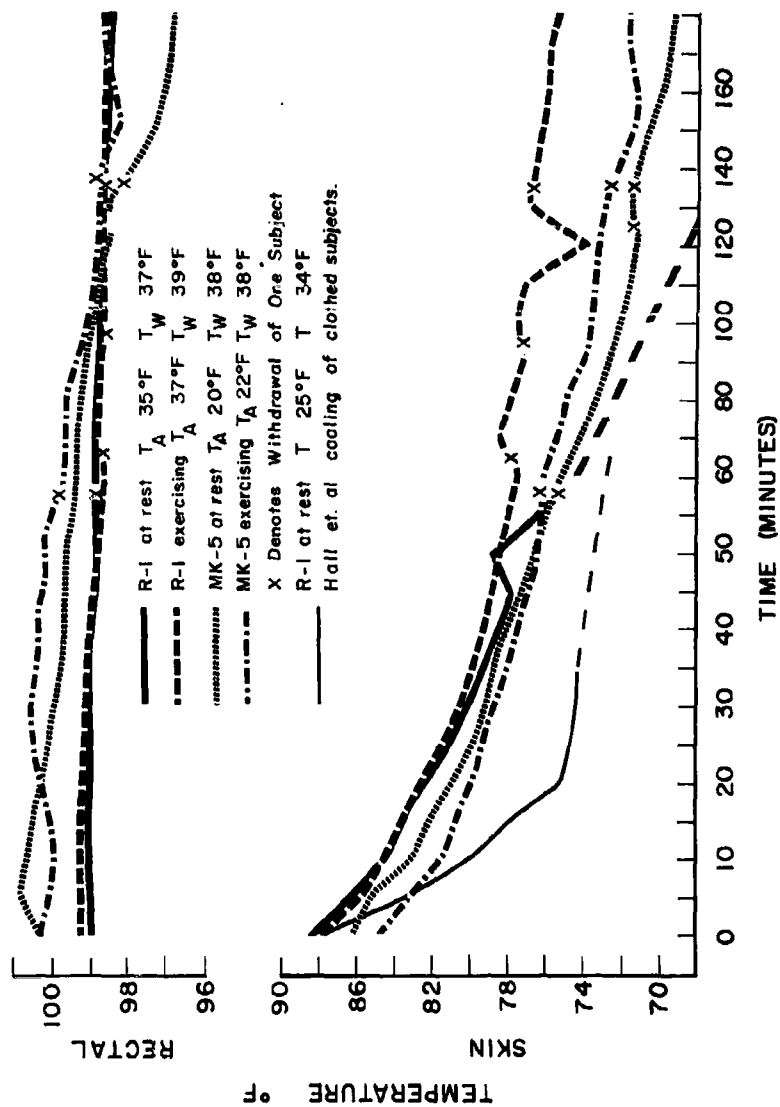
The R-1 anti-exposure assembly, seen in Figure 6, was used as a standard of comparison for wet cold results. This assembly is adequate for cold water immersion in excess of eight hours. Graph 3 shows a comparison of skin and rectal temperatures of subjects immersed wearing the MK-5 and subjects wearing the R-1. Results of immersions wearing the the R-1 were taken from previous work done in this laboratory and work done by Hall and Poulte (1955). There is no statistically significant difference in skin or rectal temperatures at the end of one hour. The MK-5 is adequate for immersions in excess of 8 hours assuming that no water is absorbed by the suit. These results would probably be altered by extreme ambient temperatures (-40° to -60° F). There is a subtle but not statistically significant difference between resting and exercising states. Extreme difficulty in exercising due to hydrostatic pressure and flotation was encountered by all subjects. Elevated rectal temperatures are probably indicative of the living conditions in the field. Critical foot temperatures (skin temperatures below 40° F) were encountered with the MK-5. This was due to experimental design and the election to wear only one pair of thin socks. Additional protection could be obtained by welding the rubber boot to the exposure suit making it impervious to water.

Results of immersions using the CSU4/P and results of nude immersions in water temperatures of 43° F performed by Benke and Yaglou (1950) are plotted on Graph 4. A comparison of these results shows the value of the CSU4/P. Based on rates of heat loss at the termination of these experiments a two hour "tolerance" or "practical rescue" time is assumed. This is in excess of the nude tolerance predictions of Molnar (see Figure 7) which are currently used as "Rescue Guide Lines." Exercise appeared to shorten this time due to increased convection of the water contained by the suit. Exercise was possible only during the first 15 to 20 minutes due to the extreme cooling of the legs and thighs.

In ambient temperatures above 0° F, "practical rescue" times may be extended through the use of rafts and through the use of additional insulation. Head gear is of utmost importance since the head and upper torso may be exposed to extreme environmental conditions.

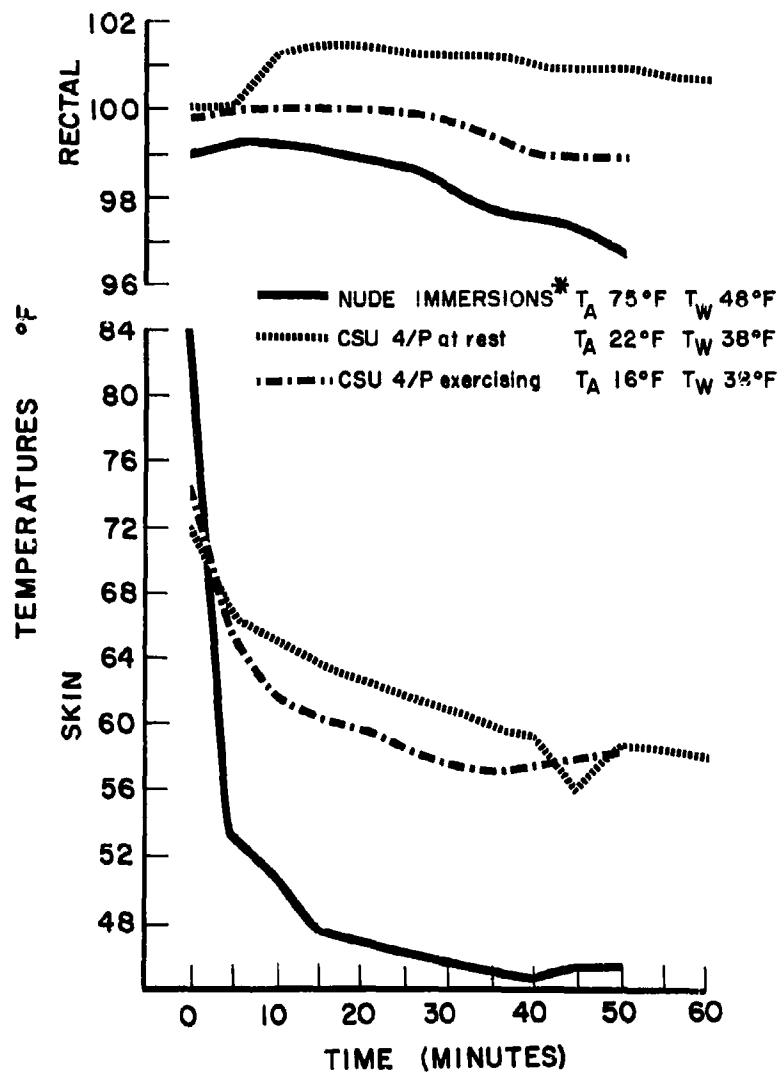


FIGURE 6. R-1 anti-exposure assembly



GRAPH 3.

Wet cold exposures of subjects wearing the MK-5 assembly



GRAPH 4.

Wet cold exposures of subjects wearing the CSU4/P assembly

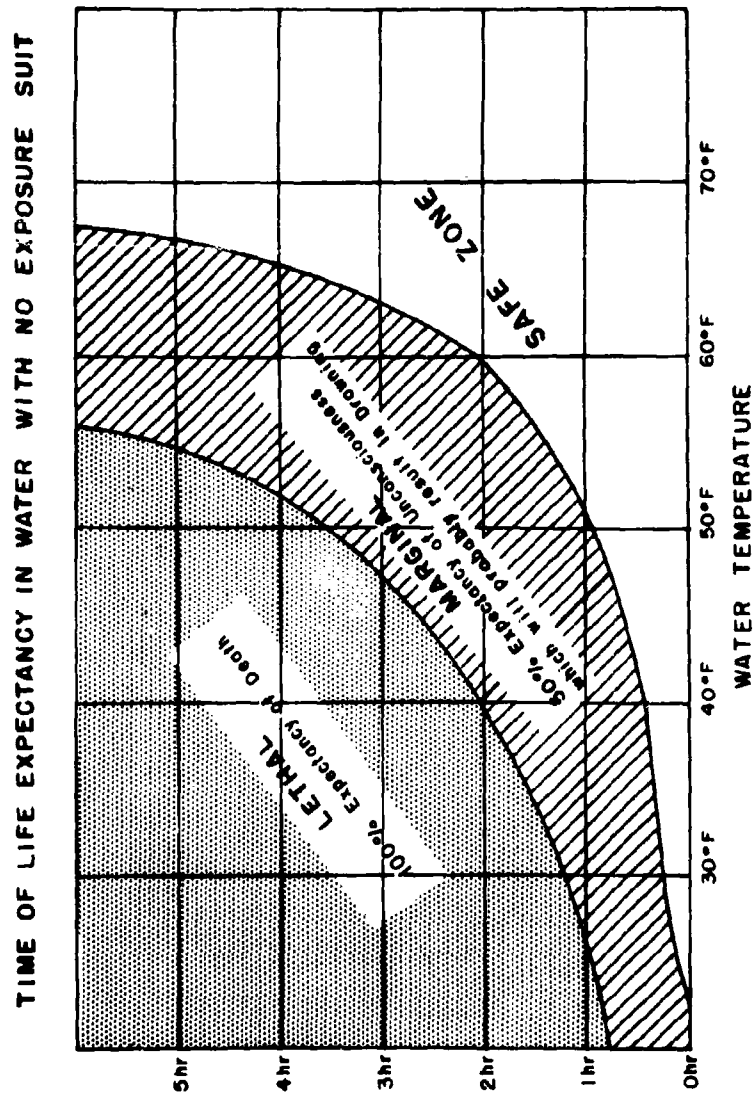


FIGURE 7. Life expectancy following cold water immersion

SECTION 4. CONCLUSIONS

The MK-5 and CSU4/P assemblies when used with additional protective equipment may be considered adequate protection for dry still air temperatures of -30° F.

The MK-5 and liner is adequate protection for water survival in excess of 8 hours. The degree of exercise necessary to obtain a significant change in skin and/or rectal temperatures is extremely difficult. The value of exercise is marginal.

The CSU4/P is adequate water survival protection for periods in excess of two hours. Exercise, which is possible for only limited periods due to extreme cooling of the legs, is of no value.

Additional insulation will increase the capability of either assembly during water immersion. Additional insulation of the head is a major consideration.

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