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PERSONNEL PROTECTION FROM COLD IN A 7 MAN LIFE RAFT

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13. ABSTRACT

A physical test was conducted to determine the protective properties of a 7 man life raft in the cold. From the known energy output of 2 heaters and 34 measured temperatures, the insulation values $\left(Clo = 0.18 \frac{C\ M^2\ hr}{Kcal}\right)$ for the total raft, its floor, ceiling, sidewalls, back and front could be derived. The raft was floating in a swimming pool and water temperature maintained at 21.50.

Overall insulation value (Raft + Air) was	1.7 clo
Raft alone	1.1 clo
Floor (23% of total inside area)	0.55 clo
Ceiling (16%)	1.55 clo
Sidewalls (43%)	1.27 clo
Front and back (18%)	0.9 clo

Two graphs show the increasing cold protection when 1 to 7 subjects occupy the raft.

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FOREWORD

The research reported in this paper was conducted by personnel of the Aerospace Medical Research Laboratory, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio in support of the Skylab program.

This technical report has been reviewed and is approved.

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SECTION I

INTRODUCTION

The probability of survival from exposure to extreme cold water depends on activity and body insulation. The natural responses of the body to cold (shivering and vasoconstriction) are not sufficient to maintain a tolerable heat exchange balance. Muscular effort to maintain the core temperature level cannot be continued infinitely. Since the thermal conductivity of water is approximately 23 times greater than that of air, it is practically impossible to provide sufficient cold protection by clothing alone due to the bulk required. Fortunately, the life raft offers additional insulative protection and the question arises how much protection can be expected. Since the survivor within the life raft is not in direct contact with the water, the insulation of the raft itself can be added to that of the survivor's clothing. A physical test can provide information about the heat flux from a subject to the environment. It may also show where major heat leakages in the raft are present and thus indicate where the raft design can be improved. It may also show how raft occupancy affects the thermal protection. However, the effect of the continually changing environmental conditions and the physiologic state of the survivor when he enters the raft can be explored only by simulation of expected environmental situations.

SECTION II

TEST CONDITIONS AND PROCEDURES

The 7 man raft was floated in a pool located in the All-Weather Room of this Laboratory. Two electrical heaters each having an output of 235 watts (470 watts = 404 Kcal/hr total) were installed in the raft and insulated from the floor by a wooden board (3/4" thick). The heaters were sandwiched between 2 aluminum plates 10" X 16" X 1/4". Thus the heat produced was transmitted mostly by the aluminum plates. Thirty-four thermistors were distributed over the inside and outside walls, the floor and ceiling of the raft. The temperatures were recorded at hourly intervals and the final reading taken after equilibrium was obtained.

The air and water temperatures were 22C. This temperature level has no specific effect on the experimental results. Any other temperature level would yield the same results. The air movement was 8M/min in the raft and 50M/min in the room.

SECTION III

TEST RESULTS

For the purpose of the experiment, it was necessary to determine the size of the inside and outside surface areas of the raft. The raft's surface areas are roughly:

	Inside of raft		Outside of raft	
AREA	SIZE M^2	% OF TOTAL AREA	SIZE M^2	% OF TOTAL AREA
Floor	2.8	22.7	5.6	29.4
Ceiling	2.0	15.9	2.9	15.2
Sidewall	5.2	43.2	7.0	36.8
Front and Back	2.2	18.2	3.5	18.6
TOTAL	12.2	100	19.0	100

The heat flux from the air inside the raft to the air outside and the heat fluxes through the floor, the ceiling, and the walls were determined.

From the heat transmission equation

$$Q = h \times SA \times \Delta t \ (Kcal/hr) \qquad (1)$$

the heat transmission coefficient

$$h = (Kcal/M^2 hr\ C)$$

was derived, since Q (Quantity of heat) = $Kcal/M^2$. Surface area SA (M^2) and temperature difference (°C) are known.

The heat transmission coefficients(h) for different raft areas and also their insulation values (I)

$$\left(I = \frac{1}{h \times 0.18}\ clo\right) \qquad (2)$$

are presented on Table 1 below:

TABLE 1

HEAT LOSS FROM LIFE RAFT AND INSULATION VALUES

HEAT TRANSMISSION COEFFICIENTS h	INSULATION VALUES ^{I}(Clo)	
($h = Kcal/M^2 hr°C$)	($Clo = \frac{1}{h \times 0.18}$)	
1) TOTAL RAFT AREA		
(INSIDE AIR TO OUTSIDE AIR)	TOTAL RAFT INSULATION	
$h_{TOTAL} = 3.34$	$I_{RAFT} + I_{AIR*} =$	1.67
RAFT ONLY:		
(INSIDE WALLS TO OUTSIDE WALLS)		
$h_{RAFT} = 5.13$	I_{RAFT}	1.08
	I_{AIR}	0.59

TABLE 1 (CONTINUED)

2) SPECIFIC RAFT SECTION AREAS

h_{FLOOR}	= 9.8	I_{FLOOR}	= 0.55 (22.7% of RAFT SURFACE)
$h_{CEILING}$	= 3.05	$I_{CEILING}$	= 1.55 (15.9% of RAFT SURFACE)
$h_{SIDEWALLS}$	= 4.39	$I_{SIDEWALLS}$	= 1.27 (43.2% of RAFT SURFACE)
$h_{FRONT\ AND\ BACK}$	= 6.0	$I_{FRONT\ AND\ BACK}$	= 0.9 (18.2% of RAFT SURFACE)

$$*I_{AIR} = I_{AIR_{RAFT}} + I_{AIR_{AMBIENT}}$$

Figure 1 indicates how much insulation (clo) is required to maintain a subject in comfort at different ambient temperatures. (Comfort is defined as a metabolic heat production level of 50 Kcal/M^2hr and a mean skin temperature of 33 C.) The graph also shows the thermal protection obtained if several persons share the raft and the protection of clothing worn. (The insulation values for the Dunlop suit and the Swedish Uni suit, environmental marine diving suits for Skylab use, and the raft are presented). The graph does not include the heat loss from cold water exposure prior to entering the raft. Total air insulation for clothing and raft was 0.6 clo (air velocity 50 M/min).

Figure 2 is essentially the same as figure 1 but this graph permits the determination of the required insulation for comfort if metabolism (M) differs from 50 Kcal/M^2hr per subject.

SECTION IV

DISCUSSION

The experimental results present a simple approximation of the thermal protective properties of this type of raft. However, extended field tests are necessary to provide information about recovery requirements from prior cold water exposure, the actual metabolic heat production in cold water and,

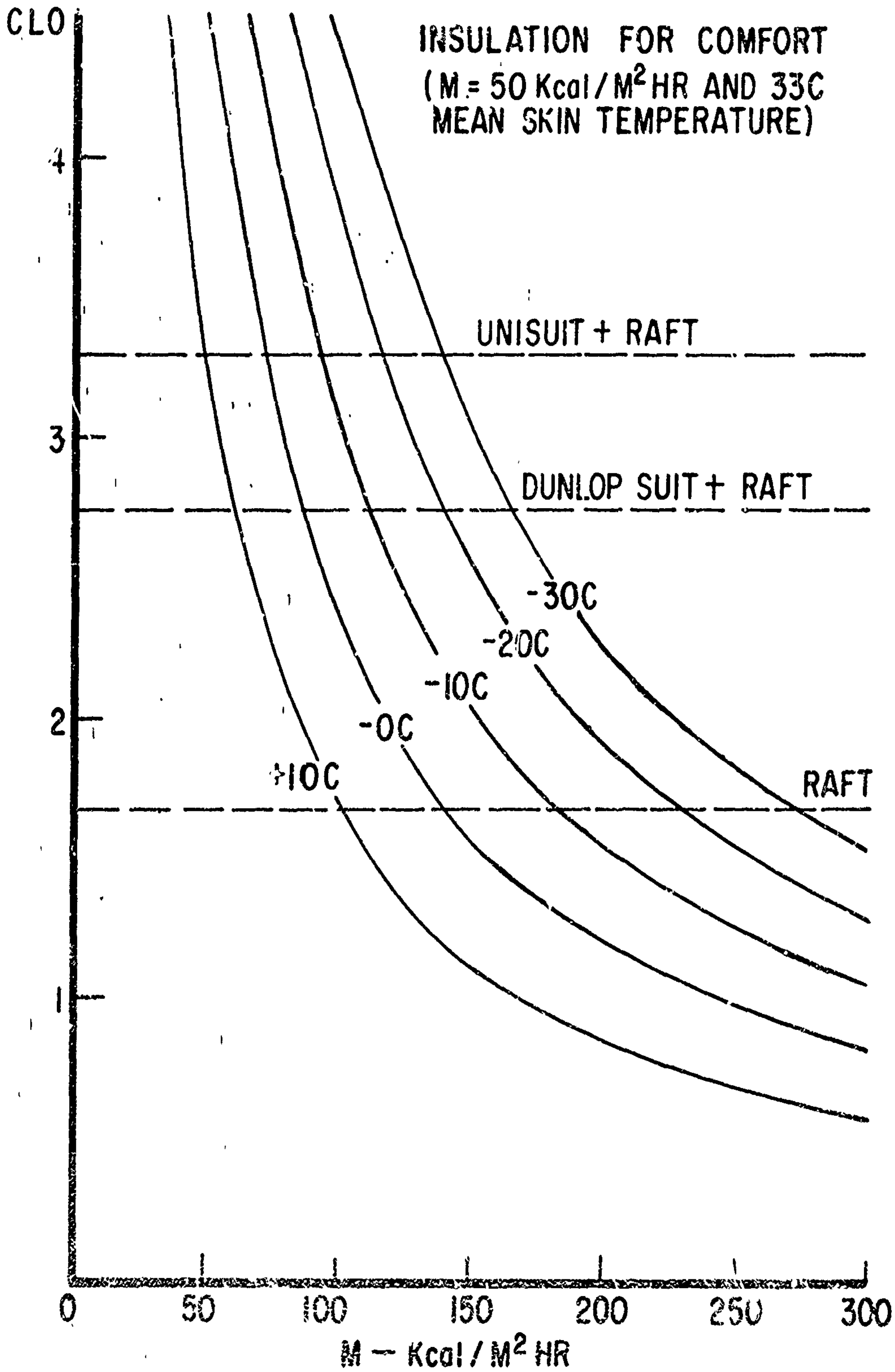
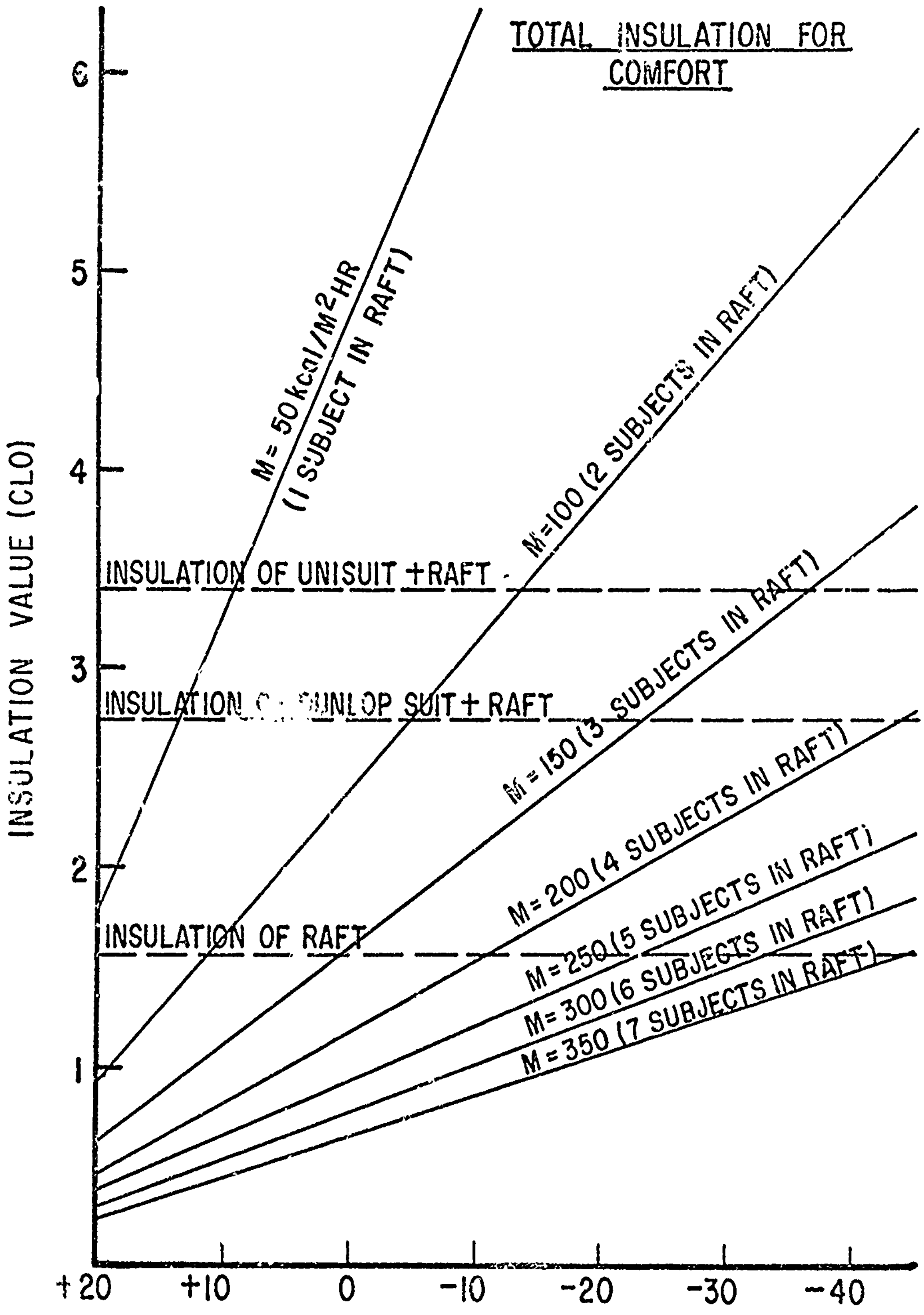


FIGURE 1. TOTAL INSULATION (CLO) FOR COMFORT AT DIFFERENT AIR TEMPERATURES AND RAFT OCCUPANCIES



''IGURE 2. INSULATION (CLO) FOR COMFORT AT DIFFERENT METABOLIC LEVELS AND AMBIENT TEMPERATURES when in the raft, as well as the effect of water and weather conditions. One should also keep in mind that factors other than the environmental conditions, such as seasickness and pressure spots of the clothing, may adversely affect the subject's tolerance.

CONCLUSIONS

1) The experimental method may be used for comparison of the insulation properties of other type life rafts.

2) The determination of regional heat transmission coefficients indicates where improvements of the raft insulation is desirable.

3) Additional subjects within the raft increase the individual thermal tolerance.

4) Field tests under severe ambient conditions are desirable.

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