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RESPIRATORY AND MICROCLIMATE TEMPERATURES WITHIN THE PARKA HOOD IN EXTREME COLD

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JAMES H. VEGHTE, CAPTAIN USAF

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**RESPIRATORY AND MICROCLIMATE TEMPERATURES
WITHIN THE PARKA HOOD IN EXTREME COLD**

JAMES H. VEGHTE, CAPTAIN, USAF

FOREWORD

This biothermal research was performed at the Aerospace Medical Research Laboratories, Aerospace Medical Division, Wright-Patterson Air Force Base, Ohio. This report presents one aspect of the internal research program being conducted by the Biothermal Branch, Physiology Division of the Biomedical Laboratory, under Project No. 7164, "Biomedical Criteria for Aerospace Flight," Task No. 716409, "Human Thermal Stress." This research began and was completed in December 1963.

This technical report has been reviewed and is approved.

WAYNE H. McCANDLESS
Technical Director
Biomedical Laboratory

ABSTRACT

The standard Air Force arctic clothing was worn to determine if it provided adequate head protection in extremely cold temperatures. Subjects were exposed to -62°C for 40 to 50 minutes in an environmental chamber. Possible respiratory problems and frostbite of the cheeks and nose were the primary concern. Subjects resting or exercising experienced no respiratory or frostbite problems. Air in the hood rapidly approached ambient conditions, because of the expulsive nature of expiration and the strong convective air movement. Exercise increased the microclimate temperatures in the hood. The existing hood design was found to provide adequate head protection for AF personnel at more extreme temperatures than are normally encountered in the Arctic.

INTRODUCTION

Despite the lack of medical evidence tissue damage from cold inspired air is still thought to be a potential hazard in cold environments. Webb (ref 1) has shown that there is no danger of inspiring air at temperatures of -31° C. The inspired air was warmed rapidly within the nasal cavities and soon reached body temperature. Little work has been done in extremely cold environments, but people do work in the Antarctic when temperatures are below -60° C for short periods (ref 2). Under these conditions, face masks are normally worn. This investigation was conducted to determine if the standard Air Force arctic clothing parka hood (without a face mask) would adequately protect a person at ambient temperatures of -62° C for a period of time - 40 minutes. Possible respiratory problems and frostbite of the cheeks or nose were the primary concern. In addition, clothing designers had always claimed that the funnel shape of the hood enhanced protection against frostbite by entrapping warm air, which provided a buffer against the extreme cold temperatures of the environment. A simple way to validate this claim was devised.

METHODS

Five subjects were exposed to a temperature of -62° C for periods of 40 to 50 minutes in an environmental chamber. These subjects were dressed in the standard Air Force arctic clothing which consisted of: shorts, t-shirt (0.2 clo), waffleweave underwear (0.9 clo), 1-piece coveralls (CWU-4/P-1, 2 clo), parka (N-3) with the hood zipped up, heavy pants (F-1B) (1.8 clo), 2 pairs of wool socks, arctic mukluk assembly (1.8 clo), arctic mittens (N-3B, 1.0 clo), and pile cap.

During the first 30 minutes of the cold exposure, the subjects stood at rest and breathed normally. Then the subject exercised by walking back and forth in the chamber. Later, four of the five subjects exercised strenuously by running in place as hard as they were able for 3 minutes. Temperatures were recorded at the end of the exercise. All subjects continued breathing through the nose during the various exercise regimes.

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1. Webb, P., "Air Temperatures in Respiratory Tracts of Resting Subjects in Cold," J. Appl. Physiol. 4:378-382, 1951.
 2. Milan, F.A., Thermal Stress in the Antarctic, AAL TR-60-10, Arctic Aeromedical Lab., Ft. Wainwright, Alaska, 1961, AD-260-213.

Air and skin temperatures were monitored by 12 thermocouples and recorded with a potentiometer. The accuracy of these measurements was $\pm 1.0^{\circ}$ C. Temperatures were monitored 6 mm inside the nasal vestibule, to monitor inspired and expired air temperatures; on the side of the nose (superior alae); and 10 other thermocouples were placed on a piece of cardboard extending through the parka hood opening at intervals of 25 mm from the cheek for a distance of 250 mm (fig. 1). The opening of the hood was 130 mm away from the cheek. The air motion within the chamber was less than 26 m per minute.

RESULTS AND DISCUSSION

The experimental data are tabulated in table 1. Air temperatures within the hood are shown in figure 2. The subjects did not experience any respiratory problem, even during hard exercise. The coldest inspired air temperature was 11° C. The coldest skin temperature on the side of the nose (superior alae) was 7° C, which was slightly cooler than the inspired air temperatures. No pain or discomfort was experienced by the subjects during these experiments. While standing at rest, the air temperature 25 mm from the cheek reached -22° C within 20 minutes. At a distance of 50 mm, air temperatures of -50° C were recorded. At distances of 75 mm or farther away from the face, but still within the hood opening, temperatures rapidly approached ambient levels. The sharp temperature drop of air within the hood during the first few minutes of the experiment results from the loss of heat stored in the clothing, and equilibrium is reached by 15 or 20 minutes. Exercise increased the air temperatures within the parka hood. Evidence from the Schlieren technique indicate that the observed air temperatures reflect the microclimate air layer surrounding the body and convective activity. The hood opening affords the lowest resistant pathway for convective loss and this loss increases as the temperature decreases. Also, Keating (ref 3) has found that the normal expulsive process of expiration carries air to a distance of one meter from a person when the pathway is unobstructed. Because of these factors, the turbulent air prevents any appreciable pooling or pocketing of warm air within the funnel of the hood.

CONCLUSION

No respiratory or frostbite problems were encountered when subjects wearing standard Air Force arctic clothing were exposed to

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- Keating, D.A., K. Weiswurm, and G.W. Filson, Movement of Respired Gas in Manned Space Enclosures. Aerospace Med. 35(3): 272, (Abstr.) 1964.

a temperature of -62° C for periods of 40 to 50 minutes. Average inspired air temperatures were within the comfort range. There does not appear to be an appreciable quantity of warm air entrapped within the hood as previously thought, but a rapid turnover occurs within this space because of the expulsive nature of expiration and strong convective air movement. The movement of air (convection) up through the clothing and out the hood opening is sufficient to maintain air temperatures above -25° C at a distance of 25 mm from the cheek. The thickness and temperature of this boundary layer of warm air appears to be increased during exercise. A barrier could be devised to impede the heat loss from the hood but it would decrease the already limited visual field. Thus, the existing hood design in Air Force arctic parkas provides adequate protection at temperatures much more extreme than normally encountered by Air Force personnel in the Arctic.



Figure 1. Experimental Arrangement of Thermocouples Monitoring the Thermal Microclimate Within the Hood of the Arctic Parka.

TABLE 1
 AVERAGE RESPIRATORY AND MICROCLIMATE TEMPERATURES (°C)

Time (min)	Nasal Vesicle (6 mm)	Superior alae	Location									
			Distance away from cheek (mm)									
			25	50	75	100	125	150	175	200	225	250
STANDING AT REST												
0	27-29	27	23	17	-7	-20	-28	-31	-32	-34	-37	-39
1	21-24	24	16	10	-16	-35	-40	-42	-43	-44	-46	-49
2	22-27	24	17	7	-17	-36	-43	-44	-42	-42	-49	-52
3	22-26	22	12	4	-23	-44	-50	-51	-51	-50	-54	-56
4	19-25	22	9	-3	-28	-45	-53	-54	-52	-53	-56	-58
5	21-25	21	6	-7	-34	-56	-56	-57	-56	-56	-58	-60
6	22-25	21	2	-12	-36	-53	-57	-58	-57	-57	-58	-60
7	20-26	20	-1	-16	-40	-55	-59	-59	-59	-59	-60	-61
8	22-26	19	-4	-20	-43	-56	-60	-60	-60	-60	-61	-61
9	19-24	18	-8	-22	-44	-57	-60	-60	-60	-60	-61	-61
10	21-25	18	-9	-27	-47	-58	-60	-60	-60	-61	-61	-61
15	18-23	16	-17	-36	-53	-60	-61	-61	-61	-61	-61	-61
20	17-22	14	-22	-43	-56	-60	-61	-61	-61	-61	-61	-61
25	17-22	14	-23	-47	-57	-60	-61	-61	-61	-61	-61	-61
30	16-21	14	-24	-49	-58	-60	-61	-61	-61	-61	-61	-61
WALKING												
32	17-21	12	-22	-50	-58	-61	-61	-61	-61	-61	-62	-62
33	16-19	12	-21	-48	-58	-61	-61	-62	-62	-62	-62	-62
34	15-19	12	-21	-47	-58	-61	-62	-62	-62	-62	-62	-62
35	16-19	12	-18	-47	-58	-61	-62	-62	-62	-62	-62	-62
36	13-18	12	-18	-47	-58	-61	-62	-62	-62	-62	-62	-62
37	15-18	12	-16	-46	-59	-61	-62	-62	-62	-62	-62	-62
38	13-17	11	-16	-46	-59	-61	-62	-62	-62	-62	-62	-62
39	14-18	11	-16	-46	-59	-61	-62	-62	-62	-62	-62	-62
40	14-18	11	-16	-46	-59	-61	-62	-62	-62	-62	-62	-62
41	14-17	11	-16	-46	-59	-61	-62	-62	-62	-62	-62	-62
STRENUOUS EXERCISE (3 mins)												
46	13-16	7	3	-38	-57	-60	-61	-61	-62	-62	-62	-62
DEEP BREATHING AT REST (4 mins)												
50	13-22	13	-	-	-	-	-	-	-	-	-	-

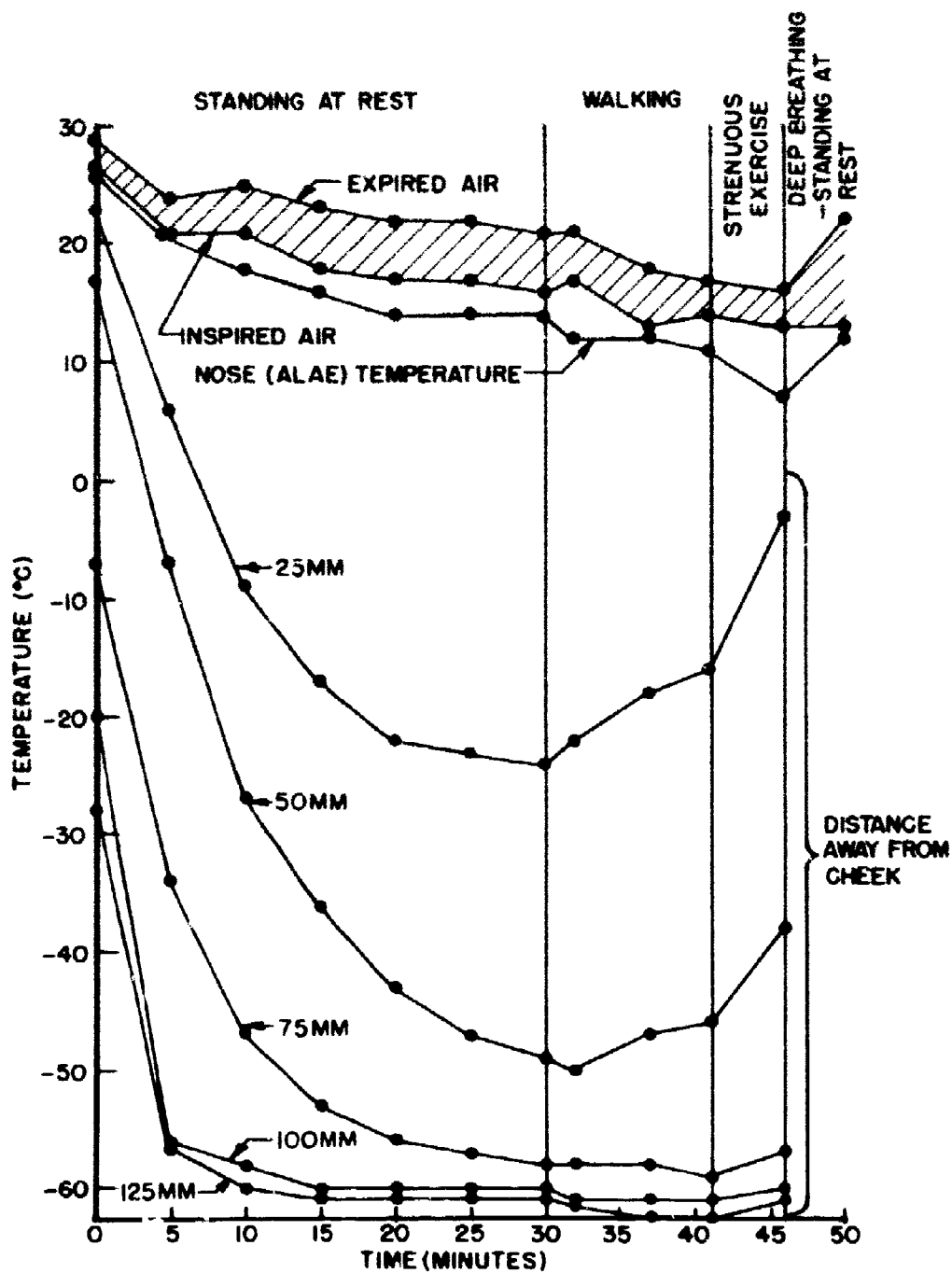


Figure 2. Effect of Activity on the Respiratory and Microclimate Temperatures in the Cold, -62° C.

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