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**AIRCREW EYE/RESPIRATORY PROTECTION (AERP):  
16-HOUR EXTENDED WEAR EVALUATION OF  
CHEMICAL PROTECTIVE EQUIPMENT**

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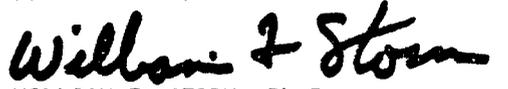
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The voluntary, fully informed consent of the subjects used in this research was obtained as required by AFR 169-3.

The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

  
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**AIRCREW EYE/RESPIRATORY PROTECTION (AERP):  
16-HOUR EXTENDED WEAR EVALUATION OF CHEMICAL PROTECTIVE EQUIPMENT**

**INTRODUCTION**

Requirements documents specified that chemical protective equipment developed under the Aircrew Eye/Respiratory Protection (AERP) program must be usable for operational scenarios lasting up to 16 h. During the Engineering, Manufacturing, and Development (EMD) phase of the AERP program, testing was conducted under many environmental conditions including acceleration (2), altitude (1, 2), and thermal stress (3). However, as noted in the recent Inspector General audit of the AERP program, the system had not demonstrated the ability to be worn for 16 h. Flight scenarios designated in the Initial Operational Test and Evaluation (IOT&E) required a maximum continuous wear of the AERP MBU-19/P mask and associated chemical protective flight clothing for approximately 13 h. Since longer scenarios have not been justified in current operational assessments, Human Systems Center/Human Systems Program Office, Chemical Defense Systems Division (HSC/YAC) decided that an evaluation simulating flight conditions within the laboratory would verify the ability of the ensemble to be worn for 16 h. This evaluation was conducted on 23 and 26 February in the Armstrong Laboratory hypobaric and environmental research chambers, human centrifuge, and Cockpit and Equipment Integration Laboratory (CEIL). The evaluation was supported by the performance assessment group within the Sustained Operations Branch.

**METHODS**

Four male subjects (two for the tanker/transport scenario and two for the fighter/attack scenario) who had previously worn standard flight clothing during at least one experimental protocol were selected from the appropriate subject pools. Each subject was fitted with the following equipment:

- Cotton long underwear (tops and bottom)
- Chemical defense flight coveralls (CWU-66/P or CWU-75/P)
- Flight boots (subjects wore personal cotton socks)
- Cotton insert gloves
- Chemical protective gloves
- Flight gloves
- HGU-55/P helmet (with custom liner)
- MBU-19/P mask/hood assembly
- SRU-21/P survival vest
- CSU-13B/P anti-G suit (fighter/attack only)
- Parachute harness with LPU-9/P (fighter/attack)
- Harness restraint (tanker/transport)

Each subject received filtered air from a CQU-7/P blower unit and during mission phases of the test scenario, breathed air or air/oxygen from an oxygen regulator (either a CRU-73/P or A-14). The fighter/attack subjects used a standard Alar hi-flow anti-G valve to inflate the anti-G suit during the centrifuge runs.

During the walk from the CEIL to the warm chamber (E), the subjects wore the protective overcaps and boots.

Flight scenarios and conditions are listed in Table 1 (fighter/attack) and Table 2 (tanker/transport).

The centrifuge profile consisted of three runs with rapid onset rate (+6  $G_z$ /s). The first run was to +3  $G_z$  for 30 s followed by two runs to +5  $G_z$  and +7  $G_z$  for 15 s each. The last run was a simulated aerial combat maneuver (SACM) of alternating 15 s plateaus at +4.5  $G_z$  and +7  $G_z$  until the subject terminated the ride or completed six +7  $G_z$  plateaus. Both subjects completed these runs both in the morning and again in the afternoon.

Each subject was familiarized with a standard performance assessment battery (PAWS) used by the Sustained Operations Branch during their aircrew fatigue studies. Each subject responded to each problem of the three different tasks displayed on a computer screen via a computer keyboard. Gloves had to be removed by the subjects during the test in order to use the keyboard. Each subject completed the battery, which takes approximately 12-15 min, before donning equipment and then approximately every 2 h during the test.

Each subject was weighed and his temperature taken orally before donning and after doffing the equipment. Heart rate was monitored at least every 2 h during the test to ensure subject safety.

The flight line (in a hot climate) was simulated using the environmental chamber (E) which was heated to 110°F as appropriate during the test scenario. The tanker/transport mission was conducted in a hypobaric chamber (C) which was depressurized at 5,000 ft/min to 8,000 ft and maintained for 10 h. The chamber was returned to ground level at 5,000 ft/min at the end of the simulated mission.

Light to moderate exercise was performed by the tanker/transport subjects during the preflight phase. This exercise consisted of walking on the treadmill for two 20-min sessions at 2.5 mph and 0° slope with a 10-min rest in between. For the fighter/attack subjects, no preflight exercise was performed due to the extreme limits of the exposure and the current operational scenario of letting a spare pilot preflight the aircraft for the crew. The tanker/transport subjects also performed light arm exercises for 30 min at 3 h and 7 h during the altitude exposure to simulate activity associated with a parachute drop or other inflight activity.

Subjects read or watched movies (or napped if appropriate in the scenario) when not tasked with other requirements of the test. The fighter/attack subjects sat in the high fidelity F-15C and F-16A cockpit mockups during the mission phase of the scenario. Each subject also drank fluids as needed via the drink tube in the mask/hood. Urine relief was allowed; however we simulated the use of "piddle packs" to simplify experimental tasks. The fighter/attack subjects mainly "rested" during the crew rest phase of the test which consisted primarily of lying down in their offices and dozing.

Additionally, the subjects each completed a comfort questionnaire (Fig. 1) and AFSC Form 3243, Crew Status Survey (Fig. 2) at the beginning, at the half-way point, and just before doffing.

### RESULTS AND DISCUSSION

All four subjects were able to wear the ensemble for the required 16 h. Body temperature and heart rate (HR) followed normal profiles for the conditions; HR remained at low levels as is typical for these fit subjects, rising only during exercise or centrifuge exposure. By the end of the day, subjects reported their fatigue levels as "less than fresh" to "moderately tired." Other than boredom and discomfort due to confinement, the following problems were documented:

1. All subjects noted moderate discomfort in the head area due to pressure points (hot spots) where the mask crossed the nose and above the forehead seal.
2. Ventilation of the eye compartment caused gradual development of red eyes and accompanying discomfort. The problem was more serious in one subject who maintained maximal blower speed throughout the test.
3. The SACM runs on the centrifuge were terminated due to severe discomfort from riding-up of the abdominal bladder of the standard anti-G suit. One of the subjects also found that inspiratory resistance in the AERP mask limited his straining maneuver.
4. The chemical defense glove assembly interferes with use of a computer keyboard and other highly tactile tasks.
5. Urine volume over the 16 h period exceeded the storage capacity of a "piddle pack." Additional emphasis needs to be placed on identifying acceptable urine relief for aircrews required to wear self-contained protective garments.

### CONCLUSION

The MBU-19/P mask/hood and associated chemical defense garments developed under the AERP program can be worn by highly motivated subjects through a 16-h period simulating aircrew duties on either transport or fighter aircraft. However, experience shows that hot spots which are tolerable for one, long day may become so sore that the equipment cannot be used again the next day, a potentially serious problem for wartime duties. Fit of the personal equipment and experience with long-term and repetitive wear will be important to minimizing discomfort and degradation of mission performance.

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2. Crist, JT and Holden RD. Altitude and Acceleration Evaluations of the Protective Integrated Hood/Mask (PIHM) for Use in Fighter Aircraft. USAFSAM/VNL letter report, 10 Oct 1990.

3. Nunneley, SA. Thermal Test of Aircrew Eye/Respiratory Protection Under Simulated Cockpit Conditions. USAFSAM/VNC letter report, 30 Nov 1987.

TABLE 1. AERP EXTENDED WEAR EVALUATION-FIGHTER/ATTACK

26 Feb 93

<u>TIME</u>	<u>LOCATION</u>	<u>ACTIVITY</u>
0330	AESOP/CEIL	S3 PAWS/S4 WT,HR,TEMP,LEADS
0345	CEIL/AESOP	S3 WT,HR,TEMP,LEADS/S4 PAWS
0400	CEIL	Don
0415	CEIL	HOODS ON (time = 0)
0425	CEIL	FA <sup>2</sup> Q/COMF
0430		walk to bldg 160, E (at 110°)
0435	E	rest
0455	E	HR
0500		exit E and walk to bldg 160, cockpits
0505	COCKPITS	mission (movies)
0600	AESOP	S3 PAWS
0615	AESOP	S4 PAWS
0645	COCKPITS	HR
0800	AESOP	S3 PAWS
0815	AESOP	S4 PAWS
0830	FUGE	S3 SACM/HR
0845	FUGE	S4 SACM/HR
0900		walk to bldg 160, E (at 80°)
0905	E	heat chamber to 110°
0935	E	cool chamber to 80°
0955		walk to bldg 170, AESOP
1000	AESOP	S3 PAWS
1015	AESOP	S4 PAWS

TABLE 1. AERP EXTENDED WEAR EVALUATION-FIGHTER/ATTACK (CONT.)

1045	CEIL	HR
1200	AESOP	S3 PAWS
1215	AESOP	S4 PAWS
1230	CEIL	FATQ/COMF
1245	CEIL	HR
1315		walk to bldg 160, E (at 110°)
1325	E	rest
1355		walk to bldg 170, AESOP
1400	AESOP	S3 PAWS
1415	AESOP	S4 PAWS
1430	COCKPITS	mission
1445	COCKPITS	HR
1515	FUGE	S3 SACM
1530	FUGE	S4 SACM
1545	COCKPITS	mission
1600	AESOP	S3 PAWS
1615	AESOP	S4 PAWS
1645	COCKPITS	HR
1800	AESOP	S3 PAWS
1815	AESOP	S4 PAWS
1835	COCKPITS	HR
1845		walk to bldg 160, E (80°)
1855	E	heat to 110° (stay 20 min)
1915	E	HR
1925	E	cool to 80°

TABLE 1. AERP EXTENDED WEAR EVALUATION-FIGHTER/ATTACK (CONT.)

1955		walk to bldg 170, AESOP
2000	AESOP	S3 PAWS
2015	AESOP/CEIL	S4 PAWS/S3 COMF,FATQ,DOFF
2030	CEIL	S3 WT,HR,TEMP/S4 COMF,FATQ,DOFF
2045	CEIL	S4 WT,HR,TEMP

TABLE 2. AERP EXTENDED WEAR EVALUATION-TANKER/TRANSPORT

23 & 26 Feb 93

<u>TIME</u>	<u>LOCATION</u>	<u>ACTIVITY</u>
0330	C	S2 PAWS baseline
0345	CEIL	weight/HR/Temp
0400	CEIL	Start Donning
0415	CEIL	HOODS ON! (time = 0)
0425	CEIL	FATQ/COMF
0430		walk to bldg 160, E (110°)
0435	E	S2 walks on TM (20 min @2.5mph)
0455	E	S2 rests (10 min)
0500	E	HR
0505	E	S2 walks on TM (20 min @2.5mph)
0525	E	S2 rests (10 min)
0535	E	chill chamber to 80°
0550	E	HR
0555		walk to C
0600	C	begin ascent, 15 min exercise
0615	C	S2 PAWS
0645	C	HR, start movie
0815	C	S2 PAWS
0845	C	HR
0900	C	S2 exercises (30 min)
1015	C	S2 PAWS
1045	C	HR
1215	C	S2 PAWS

TABLE 2. AERP EXTENDED WEAR EVALUATION-TANKER/TRANSPORT (CONT.)

1230	C	FATQ/COMF
1245	C	HR
1300	C	S2 exercises (30 min)
1415	C	S2 PAWS
1445	C	HR
1615	C	S2 PAWS
1630	C	descend to GL
1645	C	HR
1650		walk to E (80°)
1700	E	heat to 110° (hold temp 20 min)
1740	E	cool to 80°
1750		walk to C
1815	C	S2 PAWS
1830	C	watch movies or do paperwork
2000	C	S2 PAWS
2015		move to CEIL
2020	CEIL	FATQ/COMF
2025	CEIL	HOODS OFF! (time = 16)
2030	CEIL	HR/Temp/Weight



# SORENESS, PAIN AND DISCOMFORT QUESTIONNAIRE

NAME: \_\_\_\_\_

DATE/TIME: \_\_\_\_\_

**INSTRUCTIONS: RATE THE DEGREE OF SORENESS, PAIN OR DISCOMFORT THAT YOU ARE CURRENTLY FEELING FOR BODY PARTS 1-11. DO SO FOR THE FRONT AND THE BACK OF THE BODY.**

**FILL IN A CIRCLE FOR EACH BODY PART UNDER I TO II.**

**FRONT OF BODY**

1	2	3	4	5	6	7	8	9	10	11
<input type="radio"/>										
<input type="radio"/>										
<input type="radio"/>										
<input type="radio"/>										

**BACK OF BODY**

1	2	3	4	5	6	7	8	9	10
<input type="radio"/>									
<input type="radio"/>									
<input type="radio"/>									
<input type="radio"/>									

**12 13 14 15 16 17 18**

NONE							
VERY SLIGHT							
MILD							
MODERATE							
SEVERE							
EXTREME							

**NOTE:** 16, 17, and 18 apply only to FRONT of BODY  
15 applies only to BACK of BODY

FIGURE 1. Comfort questionnaire.

NAME		DATE AND TIME
<b>SUBJECTIVE FATIGUE</b> (Circle the number of the statement which describes how you feel RIGHT NOW.)		
1	Fully Alert; Wide Awake; Extremely Peppy	
2	Very Lively; Responsive, But Not At Peak	
3	Okay; Somewhat Fresh	
4	A Little Tired; Less Than Fresh	
5	Moderately Tired; Let Down	
6	Extremely Tired; Very Difficult to Concentrate	
7	Completely Exhausted; Unable to Function Effectively; Ready to Drop	
COMMENTS		
<b>WORKLOAD ESTIMATE</b> (Circle the number of the statement which best describes the MAXIMUM workload you experienced during the past work period. Put an X over the number of the statement which best describes the AVERAGE workload you experienced during the past work period.)		
1	Nothing to do; No System Demands	
2	Little to do; Minimum System Demands	
3	Active Involvement Required, But Easy to Keep Up	
4	Challenging, But Manageable	
5	Extremely Busy; Barely Able to Keep Up	
6	Too Much to do; Overloaded; Postponing Some Tasks	
7	Unmanageable; Potentially Dangerous; Unacceptable	
COMMENTS		

REPLACES AMD FORM 316, JUN 83, WHICH IS OBSOLETE.

 AFSC FORM 3243  
 JUN 85

CREW STATUS SURVEY

FIGURE 2. Crew status survey form.