WADC TECHNICAL REPORT 59-247 (I)

EMERGENCY ESCAPE CAPSULE STUDIES

PHASE I: Preliminary Laboratory Flotation Studies

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WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
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FOREWORD

This study was conducted under the direction of Mr. Ronald S. Huey and Capt. Billy J. Mills; and was initiated under Project No. 6325, "Integration of Personal Equipment," Task No. 63750, "Integration of Survival Kits." It represents one phase of the in-house research effort conducted under the above project. The major portion of the research was carried out in the test pool facility of the Aero Medical Laboratory, Wright Air Development Center. The studies were conducted during May through October 1958 by members of the Aircrew Equipment Section, Aircrew Effectiveness Branch, with the cooperation of the Clothing Branch, Engineering and Development Branch and the Physiology Branch, Aero Medical Laboratory. The author wishes to express his appreciation also for the cooperation and assistance of the Aircraft Laboratory and the Communications and Navigation Laboratory in the conduct of these studies.

Acknowledgement is made to George A. Post, USAF, and Bruce C. Barwise, USAF, for their participation as test subjects.

ABSTRACT

Preliminary studies using aircraft canopy escape-type capsules are described herein. Design of capsule clothing, donning of clothing in confined space, stowage of emergency survival items, air exchange requirements, flotation, inhabitation and communication studies were conducted as individual facets of the program. The studies were culminated with a test in which a human subject remained in a closed capsule for 72 hours.

Findings from these preliminary studies are presented.

The capsule with an air exchange system successfully served as a temporary shelter while floating in a test pool for a period of 72 hours. Throughout the test, the hatch was closed to simulate a situation which might be necessary operationally only as a result of the most severe environmental conditions.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

Fred W. Berner

FRED W. BERNER
Technical Director
Aero Medical Laboratory

INTRODUCTION

With the advent of manned supersonic air weapon systems, it was apparent that open ejection seat systems could not afford the aircrew member sufficient protection from increased windblast on ejection and exposure to the elements during descent. This resulted in a requirement for an emergency escape capsule.

Under contract, Stanley Aviation Corporation designed and constructed eight experimental capsules for basic research studies by the Air Force. The capsule, because of its inherent design requirements, would provide protection to the occupant during descent and might also provide a suitable survival shelter. The purpose of the task reported herein was to determine the feasibility of utilizing the capsule as a primary survival vehicle.

In May 1958, the Aircraft Laboratory, Wright Air Development Center, modified one of the canopy escape capsules in accordance with Aero Medical Laboratory requirements and delivered it to us for basic physiological studies relative to emergency survival conditions.

The preliminary investigation included numerous studies of individual aspects of emergency survival within the capsule. These included packaging and storage of survival items recommended by the Strategic Air Command, clothing design, establishment of air exchange requirements (CO_2 accumulation), communications, as well as capsule design considerations. Subsequently, long-term inhabitation tests were made in the closed capsule floated in the Aero Medical Laboratory test pool.

Carbon Dioxide Accumulation

The ultimate aim of these preliminary capsule studies was to conduct a test in which a human subject would remain in the capsule for 72 hours with the hatch closed. This would simulate the worst survival condition resulting from cold, rough seas which would prevent the occupant from opening the capsule.

In order to determine accumulation of carbon dioxide within the closed capsule, an infrared carbon dioxide analyzer was used. The sampling line was installed approximately 6 inches above the subject's head. A 4-inch diameter valve was installed in the hatch. This valve was designed to operate on the principle of convection. Results of the test are shown in figure 1 and table 1.

TABLE I

RESULTS OF CARBON DIOXIDE ACCUMULATION TEST

TIME	$\%CO_2$	REMARKS
0850	Start	
0855	0.75	
0900	1.25	
0905	1.25	
0910	1.75	
0915	1.75	
0920	2.25	Moderate motion
0930	2.50	
0940	2.88	
0950	2.88	Subject asleep
1000	2.75	
1010	3.25	Subject rolled over
1015	3.50	
1020	3.25	
1030	4.25	
1040	4.50	
1050	4.80	
1055	4.80	
1100	5.20	Subject circulated air
1105	5.30	Subject circulated, some symptoms noted
1120	6.00	Abort

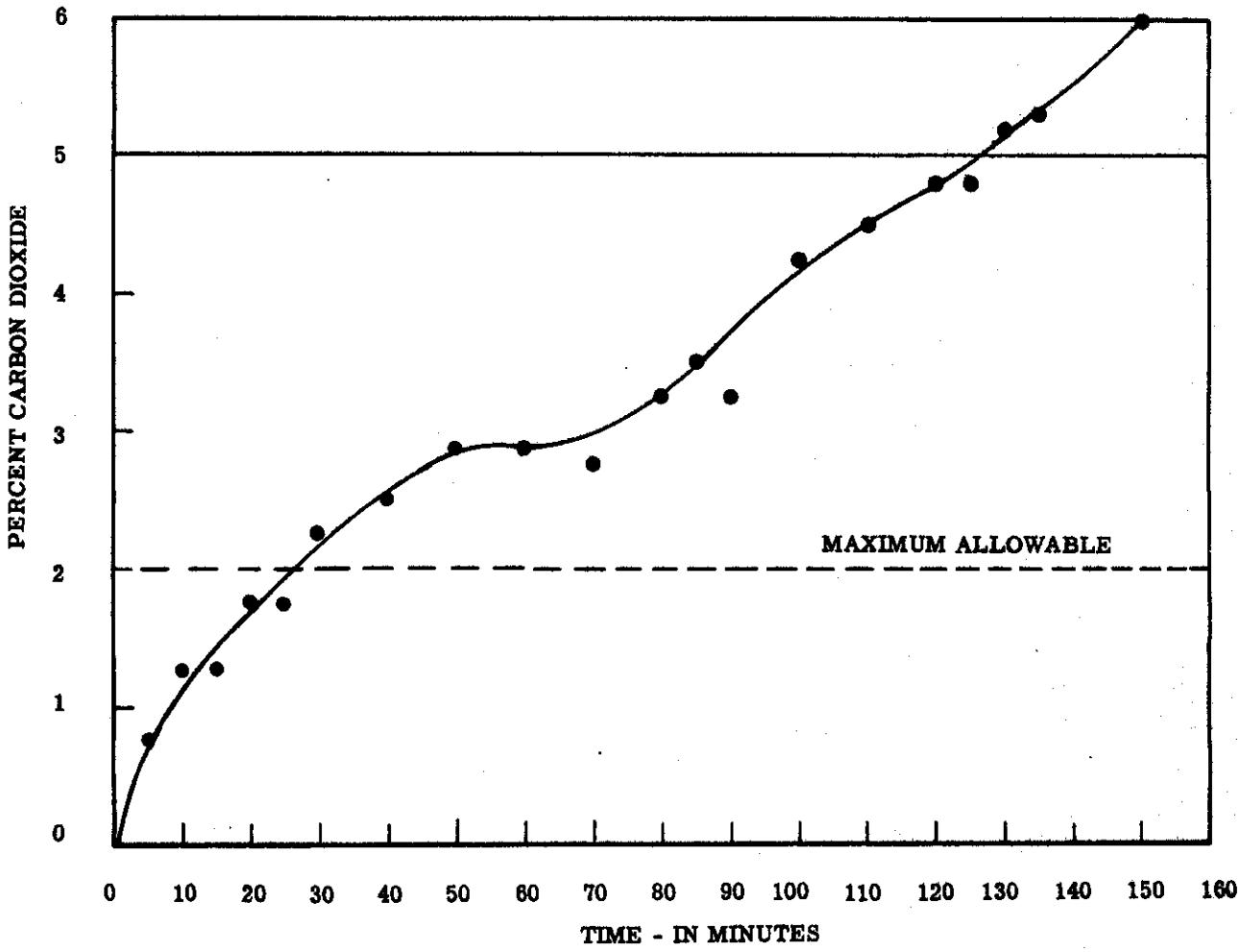


Figure 1. Carbon Dioxide Accumulation Test

Inasmuch as the carbon dioxide limit, established by the Air Force, is 2% sea level air, it was necessary to incorporate a positive air exchange system in the experimental capsule. This system is described in Section II.

Capsule Clothing Design and Donning

The Strategic Air Command determined that a requirement did not exist for multiple size clothing components for incorporation in encapsulated seats in view of excessive cost, logistics, supply and maintenance problems involved. They recommended universal size clothing assemblies be provided — designed to fit the 95th percentile man. In addition, the capsule concept eliminates the clothing, windblast and parachute landing fall requirements.

This "shirt-sleeve" concept required a new method of packaging because all survival clothing formerly worn must now be stowed. In order to keep stowage space to a minimum, it was necessary to turn to vacuum packaging of some articles. Moreover, the confined area of the closed capsule required a series of tests to determine whether the clothing could be donned without difficulty.

For these studies, the capsule containing a control stick (to determine how much of an obstacle this would present) was used (Fig 2).

Ten subjects ranging from the 5th through the 95th percentile took part in the tests. Each wore the standard shirt-sleeve equipment: the K-2B flying suit, flying boots, crash helmet and chap-type anti-g suit. They donned various clothing assemblies in the capsule with the hatch closed. The performance of each was timed and problem areas for each assembly were noted. It was found that buttons and zippers were difficult to handle (neither do they lend themselves to vacuum packaging). The results indicated that slip-on type clothing of the universal size was most satisfactory because it does not require buttons or zippers and thereby is more easily managed in the confined spaces of the capsule.

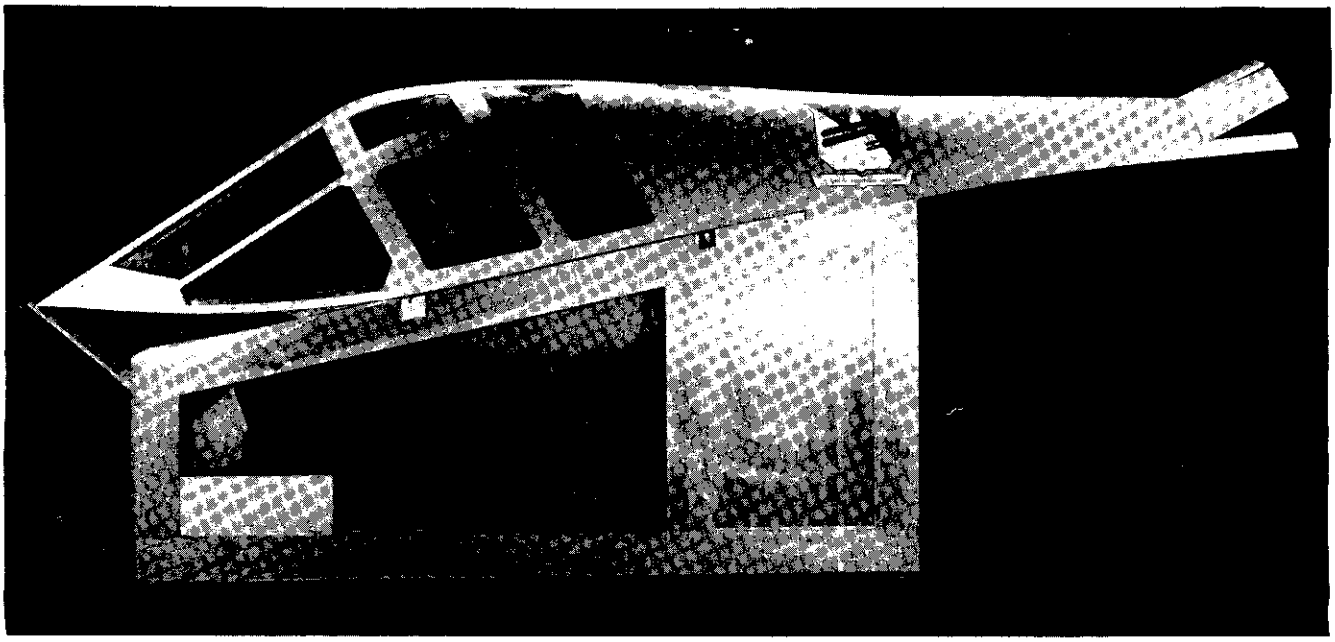


Figure 2. Stanley Canopy-type Capsule Used for Clothing Donning and Design Studies

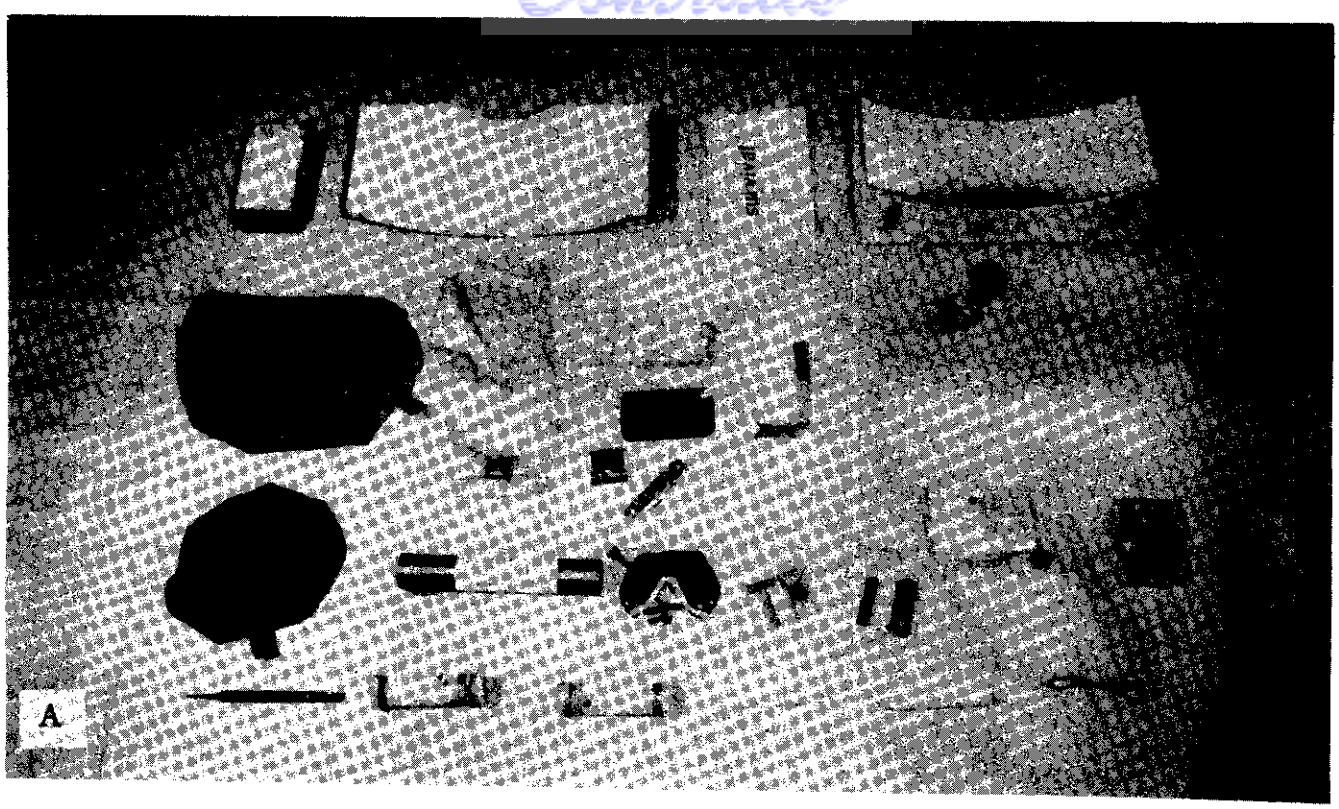
Storage of Survival Items

The Strategic Air Command recommended a group of items to be packaged and stowed in the capsule. These would be used to maintain the aircrewmen during his wait for rescue. This list (Appendix I) included clothing, rations, and emergency signaling devices to which 2560 cubic inches of space

had to be allotted. No storage areas were specifically designated for these items within a given capsule. In order to accomplish the packaging in the allotted space, vacuum packing of certain items was required. Figures 3 and 4 illustrate the survival equipment with the exception of the radio.

The metal seat originally installed in the capsule was removed and replaced with a specially fabricated wooden seat. Three metal containers were constructed to fit in this seat to provide easily accessible, removable storage space for survival items. Serving a dual function, these containers were designed as the head rest, contoured back rest, and seat pan (figs. 3 & 4). The seat and headrest were chosen as spaces most likely to be uncommitted for other sub-assemblies in the operational capsule design.

Figure 3. Seat Container and Emergency Survival Items Vacuum Packed in the Container. Universal-type Clothing is Shown at Bottom Left and at Right.



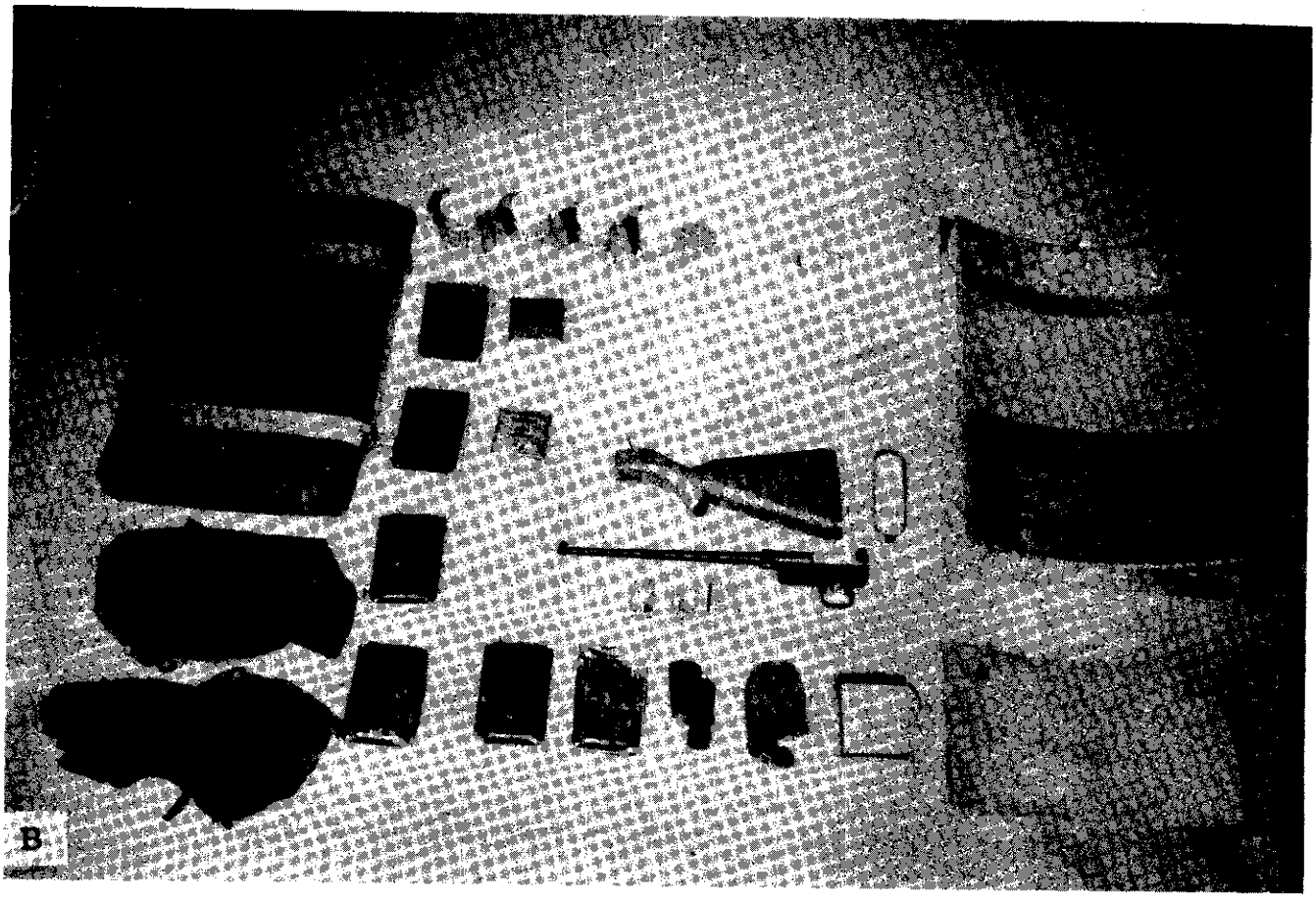


Figure 4. Emergency Survival Equipment Containers Shown with the Items Each Contain. A. Head Rest Container. B. Contoured Back Rest Container with Cushion.

The seat pan cavity was used for the vacuum package containing the MC-1 sleeping bag, universal clothing, as well as mittens, hood, wool socks and muck-lucks (Fig 3).

A completely satisfactory method of vacuum packing the clothing was not found. The plastic package expanded to nearly normal size in from 2 to 24 hours. It was therefore necessary to fasten the seat kit with a steel band to keep it from snapping open (this would be unacceptable for an operational capsule). However, additional research and development effort in vacuum packaging with the use of plastics should solve this problem.

All of the items recommended by SAC were successfully stowed in 2,560 cubic inches of space.

II. SEVENTY-TWO HOUR INHABITATION TEST

For the prolonged inhabitation test, in which a human subject was to be closed in the capsule for 72 hours while floated in the test pool facility, certain additional modifications were made to the experimental capsule. These are discussed below.

Relief Facilities

Although limited space and weight considerations for the first operational capsule, the B-58, made it very unlikely that relief facilities would be permitted, facilities for this test series were considered for two reasons. First, it was thought that no advantage would be gained by submitting the test subject to the odor and unsanitary conditions, and second, future design and operational conditions might allow and/or demand relief facilities. Any information acquired from this test series as a by-product could be invaluable for future reference. Consequently, it was decided to provide one bag for defecation and two bags of different configuration for urination (fig. 5). The defecation bag was fabricated of an outer cloth layer with a moisture-impermeable plastic inner liner; access was gained through a waterproof zippered opening. A de-oderizing agent, chemically reactant with water, was installed in the bag.

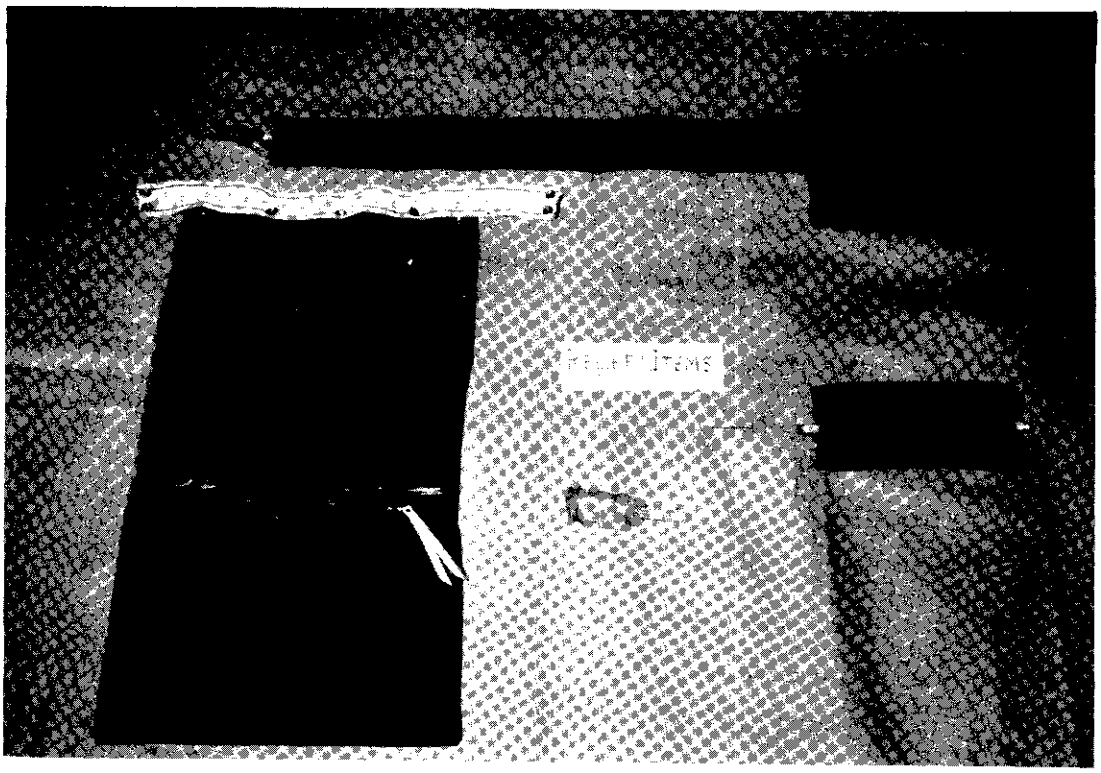


Figure 5. Relief Provisions. Lower Left: Defecation Bag. Lower Right and Upper Center: Two Differently Configured Urinal Bags.

Air Exchange System

Previous carbon dioxide studies, discussed in Section I, established that (for a period of 72 hours in the closed capsule) a method for air exchange must be furnished. However, it should be noted that the most severe condition—the hatch cannot be opened due to an extremely rough sea—might not occur with enough frequency under operational conditions to warrant penalizing the capsule by installation of a positive air exchange system.

It was thought that an oxygen mask receiving ambient air would not be satisfactory because its encumbrance would tend to influence the aircrew member to remove it. In addition, sea sickness would force him to remove the mask. Since he would not be able to detect a dangerous carbon dioxide level, this could be fatal. Therefore, a squirrel-cage blower, driven by a 24 volt DC motor (Type M.M. AC-1, Globe Industries Inc., Dayton, Ohio) was mounted in the antenna stack. The power package for the motor consisted of six 6-volt BA-210/V dry cell batteries connected in parallel. The air exchange blower was mounted to blow air into the capsule and was rated at 2 cfm at 8 inches of water back pressure. Two MD-1 anti-exposure suit check valves were installed in the hatch window. These opened at 0.5 inch of water back pressure.

Communications

The utilization of a capsule for survival following escape from an aircraft appeared to establish new requirements for a rescue communication capability. Therefore a URC-11 radio, modified to use the AIC-10 headset-microphone equipment was installed in the capsule. This permitted the subject to plug his standard helmet head-set into the survival radio. He would then be able to use the radio while descending in the capsule, as well as using it after reaching the ground. If the capsule were to be abandoned at any time after impact, the radio could be removed by unlocking a hand-operated snap. When removed from the capsule, the radio operates as a conventional URC radio. An external antenna was provided (fig. 6), and four BA-1315/U radio batteries, connected in parallel. The radio installed in the capsule for the 72-hour test had 500 hours of previous service.

Flotation

The test bed capsule seat was installed to conform to within $1\text{-}\frac{1}{2}^{\circ}$ of the angle of flotation of the B-58 capsule seat by redesigning the seat mounts. The jato pod was removed and replaced with a 200-pound weight.

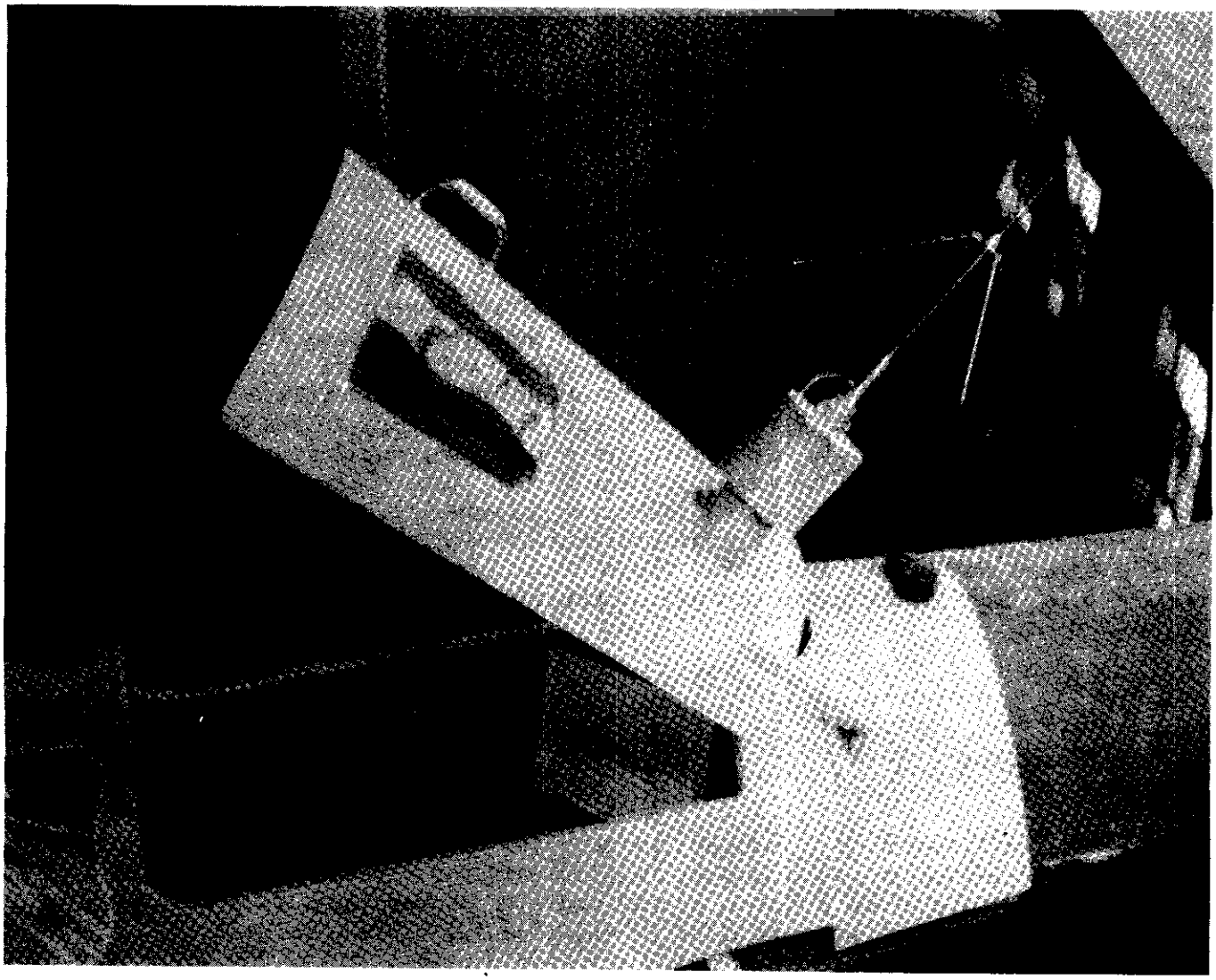


Figure 6. Emergency Survival Communications Consisting of Four Batteries (in parallel), URC-11 Radio, AIC-10 Headset and External Antenna.

TEST PROCEDURE

In October 1958, it was determined that enough of the individual aspects of emergency survival in the capsule had been resolved to conduct the over-all test in the Aero Medical Laboratory test pool. The subject, a 36 year old, male was told that various simulated conditions of survival would be presented during the 72-hour period. He was to take corrective action using the survival items at his disposal. The problems given to the subject are listed in Appendix II.

The capsule (fig. 7) was to remain closed during the entire period and the subject was to receive no outside assistance.

The subject had a "hot" mike throughout the test with which he could communicate with the test monitor. A tape recorder, operating through an APR-4 radio receiver set, recorded all transmission.

The test was conducted under the constant surveillance of the test monitor and a life guard. Qualified medical personnel had determined, prior to the test, that constant supervision by a medical officer would be unnecessary. Although he was to remain on call, a medical representative was present only at the beginning and termination of the test.

The test was begun at 1600 hours, 13 October, and was concluded at 1600 hours, 16 October 1958.

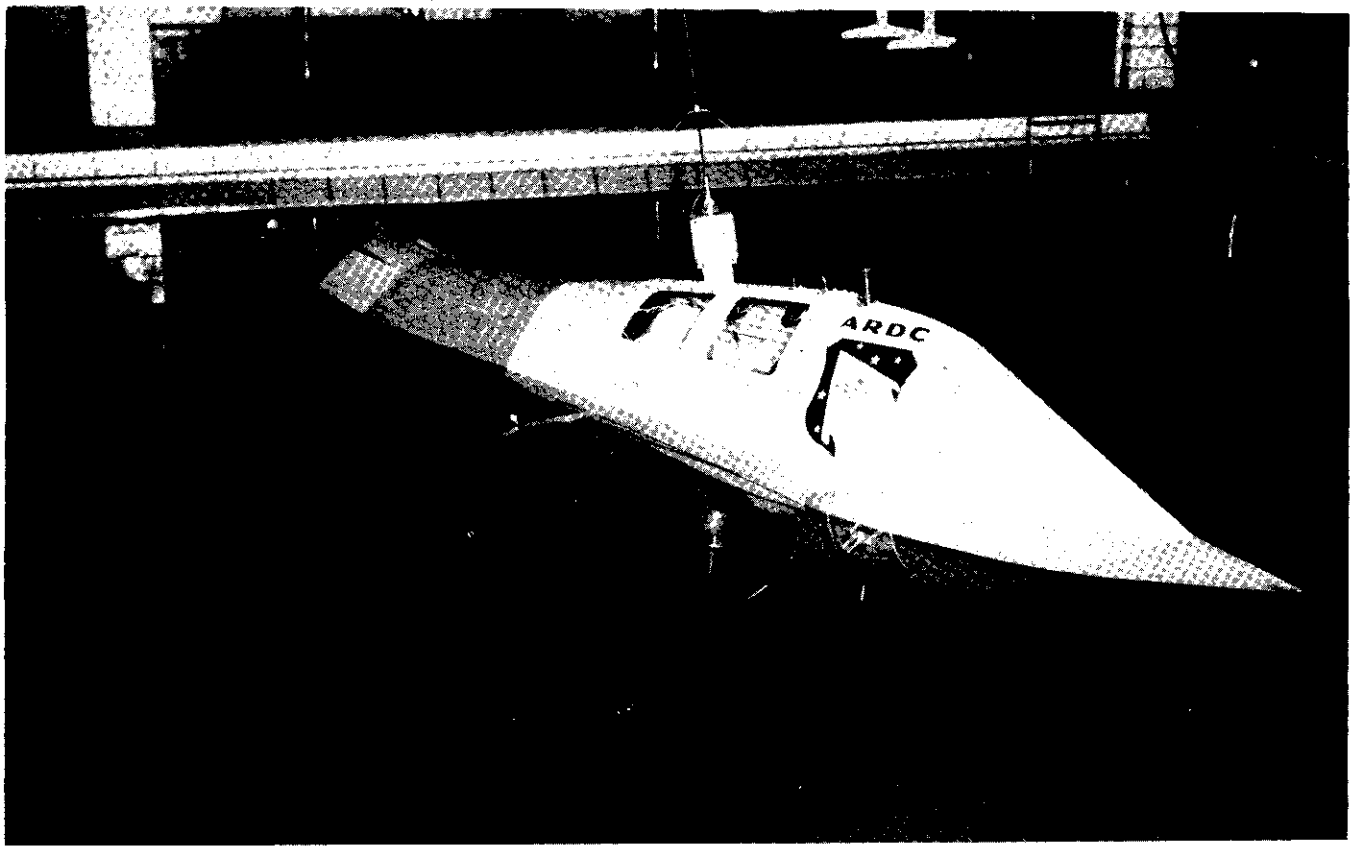


Figure 7. Stanley Canopy Type Capsule Modified for Preliminary Inhabitation Studies.

RESULTS AND DISCUSSION

The test subject, who was on a normal diet prior to the test, had no requirement to use the defecation bag. The urine facility was used with no adverse comment. The subject vomited once and this was attributed to a cereal bar obtained from the survival ration. He had several slight headaches, and mild cramps in his legs at various times. No other difficulties occurred.

The modified URC-11 radio operated continuously with no trouble. The modification of the emergency survival radio appears to offer a greatly improved method for survival use. With the installation of a flush-mounted antenna, it would be possible to transmit May-day calls with this system during the descent of the capsule.

The air exchange blower operated continuously except for one 10-minute period. The subject suffered no apparent ill effects from this. As noted earlier, the air exchange system may not be warranted for use in operational capsules.

In the test pool it was not possible to determine the stability afforded the capsule against sea wave action. However, the next phase of the program will include long term habitation tests under actual sea survival conditions.

In addition, further studies during open sea tests should determine if a valid requirement exists for interior lighting during emergency survival.

CONCLUSIONS

The recommended list of survival items, as proposed by Strategic Air Command, can be packaged within the storage limit (2560 cubic inches) if the clothing items and sleeping bag are vacuum packaged.

The universal size clothing garmets designed by the Laboratory can be donned with ease in the confined area of a closed capsule.

Emergency radio communications can be effected from within the capsule when an external antenna is provided.

A closed capsule system is capable of sustaining a human subject under simulated sea survival conditions for a period of 72 hours, provided an adequate air exchange system is incorporated.

APPENDIX I

SURVIVAL COMPONENTS FOR INCLUSION IN SAC ENCAPSULATED SEATS

ITEM (Listed by priority)	QTY	VOLUME cu in.	MAX. DIM. in.	WEIGHT lb	WEIGHT oz
RATE METER	1	70 (est)	5 (est)	3	0
RATIONS, RS-II	4	340	6-3/4	6	0
RATIONS, ST-	2	100	6-3/4	2	6
MATCHES, E-1	170	35	3	0	8
RADIO, URC-4, w/battery	1	110	5-1/2	4	8
JACKET, 100% Down, Insulated w/hood, Gerry Co, Ward, Colo.	1	150 (est)	Vac Pac	2	0
TROUSERS, 100% Down, Insulated, Gerry Co, Ward, Colo.	1	125 (est)	Vac Pac	2	0
SOCKS, 100% Down, Insulated	1	25 (est)	Vac Pac	0	8
MITTENS, 100% Down, Insulated, Gerry Co, Ward, Colo	1	25 (est)	Vac Pac	0	8
MOCCASINS, Survival Type E-1	1	20	Vac Pac	1	1
COMPASS, Lensatic	1	10		0	5
ENTRENCHING TOOL	1	75 (est)		2	0
KNIFE, Pocket	1	3	3-1/2	0	5
RIFLE, MA-1 Complete	1	90	15	3	10
AMMO, .22 Hornet, M-67	100	17	2-1/4	1	8
AMMO, .22 RF Shorts	200	10	2-1/4	0	10
KIT, First Aid	1	20	6	0	5
CANTEEN, Plastic 3 Pts capacity	1	2	12-1/2	0	2
CONTAINER, WATER, Plastic, 5 qt cap	1	3	14	0	4
SOCKS, SKI, Wool	1	7	Vac Pac	0	3

APPENDIX I (CONTINUED)

ITEM (Listed by priority)	QTY	VOLUME cu in.	MAX. DIM. in.	WEIGHT lb	WEIGHT oz
PONCHO, Light-weight	1	50	Vac Pac	2	8
NET, gill	1	4	Vac Pac	0	2
MANUAL, Survival	1	13	8	0	3
MIRROR, Signal	1	4	5	0	8
CANDLE, Long Burning	2	15	6	0	10
SIGNAL, Distress Day-Night, MK-13	2	20	5	0	8
SIGNAL, Distress Hi Altitude, M-131	1	24	10	1	8
HEADNET, Mosquito	1	2	Vac Pac	0	2
WIRE SAW	1	2	18	0	2
HEAT TABS, Box of 24 ea Speaker Corp, Milwaukee	48	26	6	1	0
GOGGLES, Ski	1	12	3	0	4
WATER, Drinking	4	64	6	2	10
STICK, Chap	1	1	2	0	2
SPOON	1	2	6	0	2
KIT, Fishing	1	16	4-1/2	0	5
RAZOR, Travellong, The Pak Co., Cleveland, O	1	2	2	0	2
WHET STONE	1	4	2-1/2	0	2
SALT TABLETS	45	9	2-1/4	0	4
SNARE WIRE	20 ft	1		0	2
SOAP TISSUES or SOAP	1 pack	7	3	0	2
COMPASS, Button, Escape	1	1	1/2	0	1
MONOCULAR	1	20	5	0	11

APPENDIX I (CONTINUED)

ITEM (Listed by priority)	QTY	VOLUME cu in.	MAX. DIM. in.	WEIGHT lb	WEIGHT oz
BAG, SLEEPING, 100% Down, MC-1	1	350	Vac Pac	5	0
AXE, Hand, 16" handle	1	40	14-1/2	1	4
FILE, Flat, 6"	1	2	6	0	2
KIT, Sea Water, Desalting	1	40	6	1	0
		1960		51	15
Estimated Packaging loss:		600			
Total cu inches & weight:		2560 cu in.		51 lb	15 oz

APPENDIX II

SURVIVAL OPERATIONS DURING 72-HOUR TEST

13 October 1958 1600-1800 hours

Equipment check, familiarization, etc.

Problems

I 13 Oct 58 2000 hours

Impact in the water following a capsule ejection; calm warm seas.

II 14 Oct 58 0700 hours

Notify subject that he can hear a plane and to take appropriate action.

III 14 Oct 58 0930 hours

Notify subject: Seas are turning cold and rough; a snow storm is approaching. Inform him that this condition develops gradually.

Obtain detailed report on donning, unpackaging, etc. As soon as subject has donned proper clothing (for protection against cold) and taken action against buffeting (helmet & lap belt), terminate test in order to prevent overheating.

IV 15 Oct 58 0430 hours

Search/Rescue aircraft and ships in the area.

Subject was notified there was to be a problem and the lights were switched off before the content of the problem was disclosed to him.

V 15 Oct 58 1030 hours

Warm tropical seas. A water spout is heading your way. Prepare for rough seas. Take action for buffeting. Helmet and safety belt. Duration of rough seas - 2 hours.

(Before daylight - If subject feels O.K. - Turn off all lights in pool area.)

Problem: Notify subject that A/C and ships are in the area on a Search/Rescue Mission. He is to take appropriate action in an effort to attract their attention. (1) Radio calls (3) Simulated Flare firing etc.
(2) Flashlight

NOTE: This condition to ascertain if a requirement for investigating interior lighting is justified.