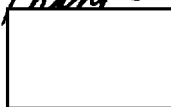


S E C R E T

OSA-1081-69

20 June 1969

MEMORANDUM FOR: Director of Special Activities
THROUGH : Deputy for Operations/OSA
SUBJECT : Report of Tests and Evaluations
REFERENCES : (1) Memorandum for DD/SA, OSA 0041-69
dated 9 Jan 1969
(2) Memorandum for DD/SA, OSA-029-69
dated 21 Jan 1969

Noted - Excellent
Thanks
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20 July

1. This memorandum is for your information.
2. One of the responsibilities of the Aero Medical Staff/OSA is to insure, through continued research, development, tests and evaluations, that project pilots have the most advanced and applicable life support equipment and training. The referenced memoranda established the requirement and the plan for evaluation of the cold-water-immersion protection provided by the S-1010 Pilot's Protective Assembly.
3. The report attached describes the preliminary evaluations conducted to date, outlines and discusses the results obtained, and establishes conclusions and recommendations. This report will then serve as a guide for AMS/OSA personnel for future evaluations, tests and modifications related to increased thermal protection.

S E C R E T

GROUP 1
Excluded from automatic
downgrading and
declassification

S E C R E T

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4. The equipment described in the report (i.e., S-1010 PPA, life rafts) are unclassified, and sensitive information related to OSA has not been included so that the report can be unclassified. This was done so that the report could be made available, without restriction, to field-level personnel at Detachments G and H and Davis Monthan and Beale Air Force Bases. Distribution, outside Headquarters, will be as follows:

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Attachment
Report, as noted

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S E C R E T

COPY # 2

EVALUATION OF COLD-WATER
SURVIVAL PROTECTION PROVIDED
BY THE S-1010 PILOT'S PROTECTIVE
ASSEMBLY AND OPEN-END LIFE RAFT

PRELIMINARY EVALUATIONS
18 March and 17 April 1969

MAJOR USAF BSC

3 June 1969

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1. Background
2. Purpose of Evaluations
3. Methods
 - a. Review of Available Data
 - b. Cold-water Survival Test of S-1010 PPA and open-end Life Raft
4. Results
5. Discussion
 - a. S-1010 PPA Thermal Protection
 - b. Open-end Life Raft - Standard
 - c. Open-end Life Raft - Improved
6. Conclusions and Recommendations

ATTACHMENTS

- #1 - Comparative Test of Aircrew Pressure Suits, Appendix B, Cold Water Survival Test, report dated 1 April 1961
- #2 - Photographs # 1 thru #16
(Copies 1 and 2 of report only)
- #3 - Proposal to Improve Thermal Protection of S-1010 PPA

1. BACKGROUND

Approximately two-thirds of the earth's ocean surface has a temperature of less than 70° F. Catastrophic failure of an aircraft over such oceans will place a pilot, who has successfully abandoned the aircraft, in a survival situation that has its greatest danger related to the effects of the cold. The lower the water temperature the greater the danger. Water has a cooling capacity (i.e., conducts heat away from a heat source) that is about 14 times greater than air. As an example, a man in normal clothing exposed to a still-air temperature of 30 to 35° F can be expected to survive a reasonable period of time, while the same man in the same clothing would perish in less than 45 minutes if immersed in water at a temperature of 30 to 35° F. The survival time for man in ordinary clothing and life preserver is reflected in the following Table I

TABLE I

Water Temp °F	Approximate range of Time Survivor can be expected to Withstand Immersion Cooling Without Fatal Results
Less than 35°	Less than 15 to 45 minutes
35° to 40°	30 to 90 minutes
40° to 50°	1 to 3 hours
50° to 60°	1 to 6 hours
60° to 70°	2 to 40 hours
70° to 80°	3 to indefinite hours*
Above 80 °	Indefinite **

* In this range, survival time is limited primarily by individual endurance.

** In temperatures above 80° F survival time is limited solely by individual endurance.

Table From Cold and Wet, Estimated Survival Time in Global Waters, ADTIC Publication G-112 dated May 1962

2. PURPOSE OF EVALUATIONS:

In view of the extremely critical nature of cold-water immersion as reflected above, it was decided to evaluate the protection provided by the S-1010 PPA. Baseline data was required on this equipment so that improvements, if required, could be appropriately designed and realistically evaluated. The life raft and certain other survival items were also evaluated with respect to their function and role in protection under extremely cold-water-survival situations. The goal of these studies and evaluations is to insure that the S-1010 Pilots' Protective Assembly and related life-support equipment, and any modifications or changes thereto, truly represents the most advanced and applicable life-support system available for its intended application.

3. METHODS

a. Review of Available Data: The most applicable data available was a test performed for USAF's Aerospace Defense Command in 1961. The applicable portion of the ADC test report is included as ATTACHMENT # 1 to this Report. The S-2 suit referred to in that report is most like the S-1010 PPA. The data shows that a pilot exposed to extremely cold water (33° F) easily survived a 15-minute immersion, followed by

1 hour 15 minutes in a one-man raft, followed by a second 15 minute immersion. The test subject wore additional thermal protection garments in the form of waffle weave long underwear, thermal socks, rubber thermal boots and exposure mittens. The maximum time an individual would be expected to withstand exposure under the given test conditions was estimated to be five to six hours.

b. Cold-Water Survival Test of S-1010 PPA and Open-End Life Raft

Since the pilots who use the S-1010 PPA would not generally wear any additional thermal protective garments (i.e., as listed above) under or over the S-1010 PPA, it was decided to initially attempt to repeat the ADC cold-water tests in a "standard flying configuration" of the S-1010 PPA. This consisted of standard light-weight cotton long underwear, light-weight socks, insulated flying boots, and the prototype S-1010 PPA. As a comparative evaluation, an exposure mitten was worn over the pressure suit glove on the left hand while only the pressure-suit glove was worn on the right hand. As a separate evaluation, unrelated to the cold-water survival tests, the prototype suit was fitted with a developmental flotation garment designed to guarantee face-up flotation for an unconscious individual. A second test was scheduled, with a second-test subject wearing additional thermal protective garments (i.e., waffle weave underwear and extra socks). The

standard project open-end life raft with orally inflatable floor and reflective cover was used in these tests.

(1) Initial and Second Test - Location and Conditions

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These two tests were conducted on 18 March 1969 in a lake in Westminister, Massachusetts, using a cabin owned by of the David Clark Company for suiting/unsuiting. A hole approximately 8 feet by 4 feet had been cut in the ice for these tests (water depth was approximately 8 feet and ice thickness approximately 20 inches at this location). Water temperature was 36° F, air temperature was between 45° and 50° F, and weather was clear and sunny with little or no wind. (See Photo #1 - ATTACHMENT #2.)

(2) Initial Test The initial test was performed by the author. The suit/underwear configuration was standard (i.e., as worn by the pilots), except for the previously mentioned developmental flotation device, consisting of cotton long underwear tops and bottoms, cotton socks, Prototype S-1010 PPA (sized to this subject), standard insulated flying boots. A non-waterproof, insulated survival mitten was worn over the PPA glove on the left hand only. (See Photo # 2 - ATTACHMENT # 2.) The subject entered the water by jumping in with helmet visor down and locked, and flotation (developmental-type) garment

inflated. Flotation position was initially as seen in Photo # 3 - ATTACHMENT # 2. Once the boots became saturated, the flotation position became as seen in Photo 4 - ATTACHMENT # 2. The subject boarded the life raft after 15 minutes immersion time. While in the life raft, the subject removed the PPA glove from the right hand and donned a special insulated mitten which attached securely to the wrist disconnect hardware. (See Photos #5, #6 - ATTACHMENT # 2). The reflective life raft cover was deployed and the subject covered himself as well as he could with the helmet still on and flotation garment inflated. No attempt was made to remove the water from inside the raft. (See Photos #7, #8 - ATTACHMENT #2). A total of 1 hour 8 minutes was spent in the raft. Prior to re-entering the water, the right-hand mitten was removed and the glove replaced. A mitten was then placed over the glove on the right hand. The developmental flotation garment was deflated and the standard S-1010 PPA flotation garment was inflated. (See Photo #9 - ATTACHMENT #2). The subject ended the test and left the water by means of a ladder after three minutes immersion time. Photos #10, #11 - ATTACHMENT #2 show the second immersion and the normal flotation position of the S-1010 PPA garment as compared with the developmental-type seen in Photos # 3 and #4. The following temperatures were recorded during the test:

Water, air, raft-water, and subject oral temperature. The oral temperature does not give a true picture of body temperature under these conditions, but only indicated a trend of body temperature.

(3) Second Test: The second test was performed by

25X1A using the same S-1010 PPA (prototype). The only difference in equipment used consisted of thermal underwear (waffle weave) and thermal socks being worn under the PPA. The subject wore a mitten over the left glove only, and used only the standard S-1010 PPA flotation garment. The prototype S-1010 PPA did not fit this subject properly and was much too large. In addition the garment was still fairly damp when it was donned. The subject remained in the water for a total of 18 minutes (see Photos # 12, 13 - ATTACHMENT #2) prior to boarding the raft. A wool mitten and an insulated mitten were donned after removal of the right glove, but the raft cover was not used. The subject spent a total of 16 minutes in the raft, with no attempt to remove water from the interior. At the end of this period, the subject was pulled from the water while in the raft and assisted out of the raft (see Photos # 14, 15 and 16 ATTACHMENT #2).

(4) Third Test: As a result of experiences with the life raft cover on the initial test of 18 March, a third test was conducted on 17 April 1969 at another lake on the outskirts of Worcester, Massachusetts. The author was again the test subject and the prototype S-1010 PPA in the standard configuration was worn. Items evaluated were specially constructed mittens (2 styles) for use with the S-1010 PPA, and a new life raft constructed with newly developed materials and fabrication techniques to reduce bulk and weight. The new raft incorporated an enlarged and inflatable cover in addition to the inflatable floor. The lake was free of ice for this test and water temperature was between 52 and 55° F. Air temperature was approximately 65° F with cloudy sky and winds between 10 and 12 mph (which would give an equivalent still air temperature of 50-55° F). The subject remained in the water for 15 minutes prior to boarding the raft. After boarding the raft, an attempt was made to bail the water from the raft with two prototype collapsible buckets. After several minutes in this endeavor, observers assisted in emptying the raft in order to get on with the test. The raft cover was then deployed, zippered and orally inflated. Approximately one hour was spent in the raft evaluating the thermal protection afforded by the inflatable cover.

4. RESULTS

a. Initial and Second Tests:

The recorded data obtained during the first two tests are presented in TABLE II (see page 10). The initial test conditions and results were reasonably realistic in terms of what a pilot might be exposed to, what he would experience, and his condition as a result of such an exposure. Certainly the conditions could well be worse with winds, rain, rough seas, and colder air temperatures. The second test, conducted to evaluate the effect of added insulation in the form of thermal underwear was not realistic since the improperly fitted suit allowed extreme suit leakage. This test would be an indicator of difficulties the pilot could encounter with additional system failures (i.e., suit leakage due to damage, removal of components, etc.).

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 INITIAL TEST

SUBJECT:

TIME	EVENTS	TEMPERATURES (° F)				RAFT	REMARKS
		ORAL	AIR	WATER			
1030	Suit donning	99.3	55	--	--	Suit was donned in a cool location, but no suit ventilation. Subject got fairly warm and sweaty during donning.	
1043	Entered water	--	46	36	--	No extreme coldness noted upon entry, but cold in crotch area shortly after due to normal slight leakage there.	
10)	Water immersion period	--	46	36	--	Right hand extremely cold, numb. Could not keep hand immersed. Left hand o.k. Noted coldness of legs and back.	
1056- 1057	Water immersion period	--	50	36	--	Shivering started at 13 minutes	
1058	Boarded life raft	--	50	36	36	Doffed right glove - replaced with special mitten - hand numb, painful. Shivering cont'd.	
1109	Closed raft cover	--	50	36	40	Shivering cont'd whether active or inactive	
1119	Raft period	97.2	46	36	40	Right hand warming up. Shivering cont'd.	
1145	Raft period	97.2	46	36	42	Right hand o.k. Shivering cont'd.	
12)	Raft period	95.8	48	36	42	Replaced glove on right hand. Shivering cent'	
1206	Re-entered water	95.8	48	36	--	Extremely cold immediately. Right hand, back, legs, crotch and feet worse. Shivering continued, violently after doffing	
1209	Ended test - left water	95.8	48	36	--	suit. For approximately 30 minutes even sitting in front of a fire in a warm room fully dressed. Feet were numb for same period. No cyanosis or skin mottling, however. Completely recovered within 1 hour.	

TIME	EVENTS	TEMPERATURES (°F)				REMARKS
		ORAL	AIR	WATER	RAFT	
1255	Suit Donning	97.8	55	--	--	Suit damp & cold when donned, as was location. Subject chilled during period. Subject partly rewarmed after completely suited and walked to lake.
1324	Entered water	97.8	45	36	--	Subject noted extreme coldness almost immediately. Felt that suit was taking on water in crotch up back and down legs.
1329	Water immersion period	--	45	36	--	Shivering started within 5 minutes. Rgt hand extremely cold.
1341	Water immersion period	95.6	47	36	--	Extremely cold and shivering intense
1342- 1345	Boarded raft	95.6	47	36	36	Replaced rgt glove with wool mitten and exposure mitten. Hand numb. Shivering continued. Left hand o.k.
1358	Ended Test - Pulled from Water	95.0	47	36	36.5	Extreme discomfort and 95° oral temperature. Judged limit to exposure. Pulled subject from water while in raft. Legs were so numb, subject could not stand unsupported at first. Needed support to walk to cabin. Violent shivering during suit doffing and for approximately 45 minutes in front of fire in cabin. Feet numb same period. Suit legs were completely wet. No cyanosis or skin mottling. Completely recovered within 1 hour 15 minutes.

b. Third Test:

The 15 minutes immersion in 52 to 55° F water was tolerated without any adverse effect whatsoever. Coldness was noted in the legs and back after 5 to 10 minutes, but the sensation was not severe and became improved after this period. The mittens kept the hands warm for the complete period, yet did not hinder raft boarding in any way. One mitten was made of waterproof material and the other was not, while insulation was the same. Protection was equal, but dexterity was better in the non-waterproof mitten. The raft, itself, was found to require a volume redistribution for this size subject since the large end did not ride high enough out of the water. Manual bailing of water was found to be impossible with the cover zippered and inflated. The reduced weight and bulk of the raft is extremely desirable for packing purposes and allows the addition of the inflatable cover. This cover provided excellent thermal protection once deployed, zippered and inflated. At the end of a one-hour period in the raft the air temperature within the covered raft was very warm and comfortable, despite fairly strong winds and moderately low ambient and water temperatures.

5. DISCUSSION

a. S-1010 PPA Thermal Protection

The results of the initial cold-water immersion test in the S-1010 PPA were as expected. Protection provided was reasonable under the conditions existing, but would be far less under worse conditions expected in certain geographical areas of operation. The results of the initial test were not expected to be as good as the results from the 1961 ADC tests (ATTACHMENT # 1), and indeed were not. However, the magnitude of difference cannot be accurately assessed because of the different environmental conditions that prevailed for the different tests. The difference in results are related to the difference in insulation used, namely the additional thermal underwear, socks, mittens, and boots used in the ADC tests. While such "add-on" protection may be tolerable for ADC aircrews flying relatively short missions originating, operating over, and terminating in cold geographical areas, aircrews using the S-1010 PPA can be expected to fly global missions which could have only a portion of the operation traversing extremely cold areas while the origin and/or destination conditions may be extremely warm. The S-1010 PPA was designed to be neutral or non-contributory with respect to fatigue production in the using aircrews. This goal has been attained

and cannot be sacrificed to provide thermal protection under emergency conditions. Therefore, any improvements that must be made in thermal protection cannot alter pilot comfort and thus must be added to the PPA and not to the pilot. Thermal underwear, socks, boots and mittens cannot be used in normal operations.

b. Open-end Life Raft - Standard

The present project raft is satisfactory for its intended use, which does not include extremely cold water survival. It was designed for and can be safely used in temperate/tropic conditions. Until new materials and fabrication techniques become available, additional thermal protection added weight and bulk that could not be tolerated in terms of packing the raft. The standard raft, as expected, was found to add little or no thermal protection under extremely cold conditions. Bailing the water out of the raft may have improved the test results, but was not done in order to keep the test conditions at their worst. Since the spray shield did not adequately cover the suited subject with his helmet on and flotation garment inflated, a pilot would not have been able to keep water out of the raft in rough seas with high winds.

c. Open-end Life Raft - Improved

The prototype raft fabricated with sonically-sealed materials provides the best combination of protection and reduced bulk/weight available anywhere. The open-end feature (same as

standard raft above) allows for ease of boarding by a pressure suited subject, even if he is injured. The open-end feature also provides additional flotation safety since the raft is divided into two cells that are separated after operating a valve to inflate the open-end after boarding. A puncture in either end leaves the pilot with at least part of his raft still inflated. The inflatable cover, once deployed, zippered and inflated, will keep a pilot warm even in the worst weather conditions. Should the raft capsize, the zipper (nylon-type) opens easily so the pilot is not trapped in the inverted raft. With the addition of a means for getting the water out of the raft while covered, a few minor modifications to zipper lanyard, and the addition of a flap covered opening for getting one arm outside the cover if required, this raft will provide the maximum protection that can be provided in a one-man life raft.

6. CONCLUSIONS AND RECOMMENDATIONS

a. Conclusions

(1) The S-1010 PPA as worn by operational aircrews provides increased cold-water immersion protection when compared with the pressure suit/flight clothing previously used in this program. The previous equipment could not be expected to provide more than 30 to 90 minutes survival time in 35 to 40°F water, while the S-1010 PPA should provide 1½ to 3 hours survival time under the same

conditions. Insulated survival mittens worn over the pressure suit gloves are required to give the S-1010A this capability.

(2) The present standard life raft cannot be expected to increase cold-water-survival time significantly over that provided by the S-1010 PPA alone. The present raft is adequate for temperate and tropic water survival in combination with the S-1010 PPA.

(3) The improved life raft, in combination with the S-1010 PPA and provided with a method for water removal, will provide significantly improved protection for cold-water-survival situations. Evaluations will be required to judge the degree of improvement.

(4) A means of providing an increased insulation value to the S-1010 PPA, without sacrificing comfort to any degree, is required in order to satisfy the following emergency survival situations:

(a) Extended cold-water immersion resulting from life raft loss or failure.

(b) Cold land survival in Arctic or near Arctic conditions with or without additional survival clothing.

b. Recommendations

(1) Minor modifications and final evaluations should be conducted on the new life raft as soon as possible. Complete

specification testing should be completed by the contractor (David Clark Company) and a report submitted. Final cold water/cold weather testing of the raft/S-1010 PPA combination should be conducted at a suitable testing location (i.e., environmental facility or Arctic environment).

(2) A developmental effort/engineering study should be conducted by the David Clark Company to determine the feasibility of incorporating an emergency insulation garment in the S-1010 PPA. An engineering study has been proposed to develop and build an inflatable anti-exposure layer for the S-1010 PPA. A brief description of this proposal, which has now been funded for, is attached (ATTACHMENT # 3). Evaluation of this garment could be conducted concurrently with final life raft evaluations if practical.

(3) Once final changes are made and incorporated in the raft and S-1010 PPA, all aircrews should receive thorough indoctrination in the new and modified equipment.