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**COCKPIT COMPATIBILITY STUDIES CONDUCTED
WITH AIRCREW MEMBERS WEARING HIGH ALTITUDE
FLYING OUTFITS IN B-57D, B-57F, F-104A, F-104B,
F-106A, AND F-106B AIRCRAFT**

FILE COPY

*REYMOND H. MIDDLETON
MILTON ALEXANDER
KENT W. GILLESPIE*

TECHNICAL REPORT ASD-TR-70-25

DECEMBER 1970

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ASD-TR-70-25

**COCKPIT COMPATIBILITY STUDIES CONDUCTED
WITH AIRCREW MEMBERS WEARING HIGH ALTITUDE
FLYING OUTFITS IN B-57D, B-57F, F-104A, F-104B,
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REYMOND H. MIDDLETON

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The distribution of this report is limited because it pertains to the development and improvement of an item of military life-support equipment.

FOREWORD

The results of compatibility tests of the A/P22S-2 and A/P22S-6 High Altitude Flying Outfits (HAFO) in the B-57D, B-57F, F-104A, F-104B, F-106A and F-106B aircraft are presented in this report. This effort was conducted under System 412A titled, "Life Support Systems." Excerpts from three trip reports are included as appendixes.

This test program was accomplished through the combined efforts of the Crew Equipment Branch (ASD/ENCCE), Crew Support Division, Directorate of Crew and AGE Subsystems Engineering, Aeronautical Systems Division; and the Anthropology Branch (6570 AMRL/HER), Human Engineering Division, 6570th Aerospace Medical Research Laboratories (6570 AMRL/HEA), Aerospace Medical Division. The authors of this report are Mr. Raymond H. Middleton, Physiologist (ASD/ENCCE), Mr. Kent W. Gillespie, project engineer for the HAFO (ASD/ENCCE), and Mr. Milton Alexander, Research Physical Anthropologist, (6570 AMRL/HER).

The authors initiated the aircraft compatibility test program and had primary responsibility for its development and implementation. In addition, the evaluation and analysis of the data and the preparation of this report were accomplished by the authors. This report was submitted by the authors 12 June 1970.

The authors are indebted to the personnel who are listed under "Persons Contacted" in each of the appendixes for their many contributions to these evaluations. The authors are also indebted to Mr. Charles K. Hodell, Branch Chief, ASD/ENCCE, and Mr. Charles Clauser, Branch Chief, 6570 AMRL/HEA, for their encouragement and review of this report and for their contribution in general to the compatibility test program; and to Mr. Kenneth Troup, ASD/SML Program Manager, who made the necessary arrangements for personnel and aircraft at various AF Bases.

ASD-TR-70-25

This technical report has been reviewed and is approved.

A handwritten signature in black ink, appearing to read "G. P. Santi".

G. P. SANTI
Chief, Crew Support Division
Directorate of Crew and AGE
Subsystems Engineering
Deputy for Engineering

ABSTRACT

This report presents anthropometric measurements of the aircrewmen, dimensions of the aircrewmen while wearing the High Altitude Flying Outfit (HAFO) in the uninflated and inflated state, and measurements of the clearance between the aircraft cockpit canopy sills and the aircrewmen seated in the ejection seat when the seat is in the bottom, neutral, and fully raised positions. All aircrewmen were measured in accordance with WADC TR 56-365, A Height-Weight Sizing System for Flight Clothing. The aircrewmen were clothed (fitted) according to these measurements.

The dimensions of the aircrewmen in the HAFO and the dimensions of the aircraft cockpit canopy sills and ejection seat were evaluated with regard to compatibility and crew-member mobility, visibility, and ability to carry out emergency escape procedures and normal aircraft control operations. It was within these areas that tests and evaluations were conducted, with the results noting those conditions which were unsatisfactory or would degrade the operational capabilities of the aircrew member to function under normal and emergency conditions.

The outfits and aircraft referenced in this report were compatible with the outfits uninflated; however, with the outfits inflated, some difficulty was experienced.

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SECTION I
INTRODUCTION

Problems arise in the integration of pilots wearing high altitude flying outfits and other protective equipment into cockpits which have not been designed to accept these configurations of pilot and equipment. Such items as pressure suits, anti-g suits, survival coveralls, etc., designed to protect the wearer during adverse environmental conditions, add as much as 10% growth to the wearer's body when nonfunctional and 30% when functional (inflated). To compound the problem, the types and amount of protective gear vary from aircraft to aircraft and mission to mission even within the same aircraft.

Such a problem, typical of the above situation, has been most evident in the B-57D, B-57F, F-104A, F-104B, F-106A, and F-106B aircraft. The data presented herein are results of tests conducted to study the compatibility of A/P22S-2 and A/P22S-6 full-pressure-suited pilots with cockpits of the above reconnaissance and fighter aircraft.

SECTION II

DISCUSSION AND EVALUATION OF AIRCRAFT COMPATIBILITY

A series of compatibility tests and evaluations utilizing the A/P22S-2 and A/P22S-6 High Altitude Flying Outfits (HAFOs) have been conducted and completed in the B-57D, B-57F, F-104A, F-104B, F-106A, and F-106B aircraft. These evaluations were conducted to determine the effects on body clearance, if any, and the performance of aircrewmembers wearing the outfits, inflated and uninflated, in regard to aircraft cockpit opening, seat ejection, cockpit compatibility, mobility, visibility, and ability to carry out emergency escape procedures and normal aircraft controls operations.

The compatibility evaluations consisted of a multiplicity of measurements including those of the anthropometric nude body of aircrewmembers, aircrewmembers wearing the outfit, the cockpit and ejection seat, and aircrewman's reach in the horizontal and vertical plane. Also, visual field observations were made with the outfits inflated and uninflated (see Appendixes I and II). Measurements and observations were made on aircrewmembers when the ejection seat was bottomed, at the neutral point, and in the fully raised positions (see Appendixes II and III). The photographs in each appendix show the distance between the arms and the canopy sills of the cockpit when the aircrewmembers are at any ejection seat level with the outfit inflated or uninflated (see tables in each appendix). Also, note that the arm reach envelope, in regard to the aircrewman's manipulation of instruments, ability in properly reaching the D-ring, or actuating triggering device with arms on armrests and spinal-body alignment including head position with respect to ejection seat headrest, can be performed with varying degrees of facility and accuracy depending on inflated outfit conditions.

The aircrewmembers were measured at the torso and upper extremities (in laboratory) either seated in an F-102 ejection seat and/or standing, or sitting reaching for the D-ring. Table I shows the comparative differences in growth rate of a typical A/P22S-2 Outfit when the subject is seated in the classical position (an anthropometrical position in which a man sits erect without slump) with and without parachute harness and life preservers, shoulder harness and lap belt fastened, and the flying outfit in the uninflated and inflated state. Conditions also are given in the table with the arms in the armrest and hands

TABLE I
COMPARATIVE DIFFERENCES IN GROWTH RATE OF
A TYPICAL A/P22S-2 OUTFIT

Subject: KWG
Suit Size: Extra Large Long
Type: A/P22S-2
Height: 70.0 inches
Weight: 200 pounds

Nude*, classical position

1. Elbow-to-elbow breadth	22.5 inches
2. Mid arm-to-mid arm breadth	20.3 inches
3. Shoulder breadth	19.8 inches

D-ring position, nude

1. Elbow-to-elbow breadth	8.9 inches
2. Mid arm-to-mid arm breadth	14.0 inches
3. Shoulder breadth	18.8 inches

With outfit, classical position, uninflated

1. Elbow-to-elbow breadth	22.6 inches
2. Mid arm-to-mid arm breadth	20.7 inches
3. Shoulder breadth	19.8 inches

With outfit, D-ring position, uninflated

1. Elbow to elbow breadth	12.5 inches
2. Mid arm-to-mid arm breadth	17.1 inches
3. Shoulder breadth	18.3 inches

With outfit, classical position, inflated (3.5 PSI)

1. Elbow-to-elbow breadth	25.4 inches
2. Mid arm-to-mid arm breadth	22.2 inches
3. Shoulder breadth	20.4 inches

With outfit, D-ring position, inflated (3.5 PSI)

1. Elbow-to-elbow breadth	15.4 inches
2. Mid arm-to-mid arm breadth	18.2 inches
3. Shoulder breadth	18.6 inches

*Nude - with one set of standard lightweight, long cotton underwear.

TABLE I (CONTD)

With outfit, inflated (3.5 PSI) classical position, B-5 with LPU-2/P

1. Elbow-to-elbow breadth	30.6 inches
2. Mid arm-to-mid arm breadth	26.2 inches
3. Shoulder breadth	23.9 inches

With outfit, inflated (3.5 PSI), D-ring position, with LPU-2/P preserver and B-5 parachute

1. Elbow-to-elbow breadth	22.4 inches
2. Mid arm-to-mid arm breadth	23.5 inches
3. Shoulder breadth	22.6 inches

With outfit, uninflated, sitting in the F-102 seat, classical position, with B-5 parachute and LPU-2/P preserver

1. Elbow-to-elbow breadth	22.6 inches
2. Mid arm-to-mid arm breadth	20.9 inches
3. Shoulder breadth	20.5 inches

With outfit, uninflated, sitting in the F-102 seat, D-ring position, with B-5 parachute and LPU-2/P preserver

1. Elbow-to-elbow breadth	15.6 inches
2. Mid arm-to-mid arm breadth	18.5 inches
3. Shoulder breadth	19.9 inches

With outfit, inflated (3.5 PSI), sitting in the F-102 seat, classical position, with B-5 parachute and LPU-2/P preserver

1. Elbow-to-elbow breadth	31.8 inches
2. Mid arm-to-mid arm breadth	26.3 inches
3. Shoulder breadth	23.7 inches

With outfit, inflated (3.5 PSI), sitting in the F-102 seat, D-ring position, with B-5 parachute and LPU-2/P preserver

1. Elbow-to-elbow breadth	23.0 inches
2. Mid arm-to-mid arm breadth	23.3 inches
3. Shoulder breadth	21.1 inches

gripping the triggering device, or seated and reaching between the legs for the D-ring. It is in these positions that it is felt that additional studies should be conducted to determine body-spinal alignment, and the feasibility of some degree of outfit protection during ejection especially with the flying outfit inflated.

During the routine compatibility tests when the aircrewmembers were seated in the cockpit and various measurements were being made, the following questions were asked of the observer and/or the outfit subject (these questions are not answered specifically in the report, but the information has been included in the appendixes).

- a. Is this the first time you have worn a HAFO?
- b. Can you reach all instruments within the reach envelope?
- c. Can you get both hands on the D-ring? If not, how many fingers of each hand?
- d. Do you consider that you can produce sufficient pull to actuate the D-ring?
- e. Is the aircrewman's head resting on the seat headrest?
- f. Can the observer determine the alignment of head and spinal column?
- g. How is the alignment of the elbow-to-shoulder area in regard to canopy sills on either side?
- h. Will the arms rub the side of the canopy sills?
- i. Is there sufficient clearance for the knees and legs at the aircraft instrument panel when the outfit is inflated?
- j. Are the feet in the stirrups during ejection phase with outfit inflated?
- k. Is there complete arm, shoulder, and leg clearance at all seat adjustment levels?
- l. With the head on the headrest, does the body have proper alignment when the aircrewman is actuating the D-ring?
- m. What are the transverse clearances at the shoulder level in regard to the canopy sills when the ejection seat is bottomed?

As a result of these questions and supplemental observations and measurements, it was concluded that this phase of the compatibility test program could be included in the routine indoctrination procedures of the HAFO program. It is within these areas that all measurements, tests, and evaluations were conducted with the results reflecting those aircraft cockpit/suit sizing discrepancies that fall outside the aircraft compatibility envelope.

SECTION III

CONCLUSIONS

The recent cockpit compatibility studies of the A/P22S-2 and A/P22S-6 outfits in B-57D, B-57F, F-104A, F-104B, F-106A, and F-106B aircraft have resulted in the general conclusion that there may be mobility, integration, and operational problem areas which can be identified only by requiring each individual aircrew member, when initially fitted in a HAFO, to be seated in a cockpit or mockup of the aircraft in which he will be flying. The aircrewman while in the outfit in the cockpit should assume an ejection position while the ejection seat is raised on the ejection rails to determine if the safe ejection dimensional envelope is exceeded. He should attempt to reach and operate all of the necessary controls in the aircraft. The above actions should be accomplished with the flying outfit uninflated and also inflated to the maximum anticipated equivalent pressure (i.e., 60,000 feet ambient altitude requires 125mm Hg suit pressure, etc). The aircrewman should use the outfit operationally in the aircraft only if he and a qualified observer or observers are confident that the above tasks and ejection from the aircraft can be performed in a satisfactory manner.

It was concluded that an aircrewman wearing either of the flying outfits, seated in the front cockpit of the F-104A, F-104B, F-106A, and F-106B aircraft with the outfit in the uninflated state, could reach all necessary instruments, radio, stick, throttle, D-ring, and armrest triggering device with very little difficulty (see Appendix III). The knees and legs of the aircrewmen were in good ejection position. The aircrewman's head position presented questionable measurements with regard to distance from the headrest. Most aircrewmen's heads were 3 to 5 inches away from the seat head rest. This position may not assure the aircrewman of satisfactory body-spinal alignment before and during ejection procedures.

SECTION IV
RECOMMENDATIONS

It is recommended that a special program be included in the routine indoctrination of aircrewmen in the use of the HAFOs that would increase the aircrewman's awareness of the factors involved in the event of an ejection at high altitudes with the outfit inflated. The aircrewman should be trained and indoctrinated in ejection procedures, outfit mobility, visibility restrictions, and operational and emergency procedures in the cockpit inflated outfit environment.

It is also recommended that a program be initiated for further study on spinal alignment in the flying outfit during the uninflated and inflated states and a determination be made of the requirement for additional body protection during emergency escape.

APPENDIX I

COMPATIBILITY TESTS OF A/P22S-6 IN
COCKPITS OF B-57D, B-57F, F-104A,
and F-106A AIRCRAFT

Tests in F-104A and F-106A conducted at
USAF Hospital, 4756th Physiological Training
Flight (PTF), Tyndall AFB, Fla.

Tests in B-57D and B-57F conducted at
58 WRS, 58 OLS, Kirtland AFB, NM.

December 1968

1. GENERAL DISCUSSION

a. In August 1968, fit tests were conducted at Edwards AFB by USAF (AFFTC) and contractor (David Clark Company) personnel on special mission aircrew members wearing DCC HAFO P/N S901-J. The figures show 48.2% downgrading in suit size, 12.0% upgrading in suit size, 29.3% in the indicated size, and 10.4% in specially sized suits. In December 1968, Wright-Patterson AFB personnel fitted and then measured 22 subjects in the A/P22S-6 suits at Tyndall AFB, Florida. Three of the subjects who wore the small short suits could have worn a smaller suit if it were available. The latest figures in these evaluations show a downgrading of 75%, indicated size 23%, and upgrading 2%. However, it was noted that 12 of 17 were downgraded because of height, and the others were downgraded due to weight. The percentage of downgrade would be higher if the smaller subjects could have had a suit small enough to fit them.

b. After the 22 subjects were measured, it was determined that downgrading was excessive and few, if any, of the extra large suits would be utilized. The initial purchase on Contract F33657-68-C-0833 (pressure suit being received at Tyndall), Table I-1, shows 10 extra large suits being procured. The trend in fit and measuring analyses showed that only two would be used according to the present MAC personnel inventory. Therefore, due to predictable excessive downgrading in the initial quantity of suits, it seemed apparent that no extra large sizes should be bought in the second purchase of suits. Table I-1 also shows the second quantity and the A/P22S-6 suits that will be in Tyndall AFB inventory, and the total inventory after the two quantities are purchased. Due to problems resulting from the attempt to fit subjects in the A/P22S-6 coverall indicated size range, the David Clark Company (DCC) devised a new sizing chart (Table I-2) which might be used as a guide for downgrading the A/P22S-6 suits.

c. Cockpit compatibility tests wearing the A/P22S-6 suits were made in the B-57D, B-57F, F-104A, and F-106A, but time and aircraft availability did not permit a complete study. Major Lehman arranged for an F-104A from Homestead AFB to come to Tyndall AFB and the F-106A simulator at Tyndall was utilized (see Attachments 1 and 2).

TABLE I - I

THE A/P22S-6 FULL PRESSURE COVERALL REQUIREMENTS AND
ADJUSTMENTS IN REGARD TO INITIAL AND SECOND QUANTITIES
PURCHASED ON CONTRACT F33657-68-C-0833

Coverall Sizes	Initial Quantity	Second Quantity (recommended)	Total Adjusted Quantity
Extra Large Long	3	0	3
Extra Large Regular	6	0	6
Extra Large Short	1	0	1
Large Long	15	4	19
Large Regular	15	3	18
Large Short	1	2	3
Medium Long	6	21	27
Medium Regular	16	15	31
Medium Short	1	3	4
Small Long	4	19	23
Small Regular	3	5	8
Small Short	1	0	1

TABLE I - 2

THE DAVID CLARK COMPANY HEIGHT-WEIGHT CHART DESIGNED
FOR USE WITH THE A/P22S-6 FULL
PRESSURE SUIT

Height (inches) - Less than	Weight (pounds) - More than	Size Recommended
65.90 68.90 71.90	149	Small Short Small Regular Small Long
67.40 70.40 73.40	174	Medium Short Medium Regular Medium Long
68.90 71.90 74.90	199	Large Short Large Regular Large Long
70.40 73.40 76.40	224	Extra Large Short Extra Large Regular Extra Large Long

d. A complete set of helmet liners was not shipped from DCC (a complete set was not ordered by MAC due to head sizes of personnel available) and several of those that were received had to be upgraded due to tightness, microphone, and head positions. The heads of all 22 subjects were measured and fitted with helmets and upgrading resulted. The noise from the helmet mounted oxygen system has been reduced to a level which is tolerable to the pilot. During normal flight in the B-57F "hot" mikes are always used.

2. CONCLUSIONS

a. As a result of the anthropometrical analyses and fit testing of the A/P22S-6 suits, most of the suits were downgraded to the next size range or below. This led to the development of a new fitting chart designed especially for downgrading the A/P22S-6 suits. This sizing range of full pressure suits (FPS) significantly deviates from the standard USAF 12-size, height-weight program that is presented in the WADC TR 56-365, A Height-Weight Sizing System for Flight Clothing. The DCC FPS design is based mainly upon its

experience gained during the S-901 "J" FPS sizing program, the results of which are indicated in Paragraph 1a of the General Discussion.

b. Twenty-two A/P22S-6 suits were measured and analysed which was a sufficient sample to show total downgrading and a need for a revision in the predicted sizes required for the purchase of the second quantity of suits (see Table I-1). A conclusion was reached in regard to the total number of suits that would satisfy Tyndall's inventory requirements for MAC aircrew personnel.

c. The personnel at Tyndall AFB provided ASD/ENCCE with a report on the fitting of helmet liners after a full range of sizes has been received and fitted on a large sample of subjects. Several methods of fitting were suggested.

d. The cockpit compatibility tests on the F-104A, F-106A, and B-57D aircraft were incomplete due to the availability time of the aircraft. Compatibility tests conducted in the B-57F were sufficient to give a trend as to what might be expected from the use of a full range of suits in that aircraft.

f. The use of a full pressure suit in any aircraft with ejection seat armrest handles causes the shoulder breadth of the subject to be at a maximum due to arm position for ejection. On aircraft with a D-ring between the legs, the ejection activation mode allows the shoulder breadth to be minimal with the arm position in front of underarm life preservers. A minimal shoulder breadth is desirable for a safe ejection, particularly on a large man.

ATTACHMENT 1 TO APPENDIX I

COCKPIT COMPATIBILITY TESTS OF F-104A AND F-106A AIRCRAFT

The information in this Attachment illustrates a quick sampling check of cockpit compatibility in the F-104A and F-106A aircraft. Time did not permit a complete check which would be necessary for a small cockpit of this type. One should observe the measurements of the internal width of the cockpits (sill-to-sill) against the measurements in Table I-3 of nude subjects and Table I-4 showing the subjects in inflated suits. The cockpit width of the F-106A at the seat (rear) position is 27.7 inches across. The cockpit of the F-104A at the pilot's seat is 25.7 inches. It is the opinion of the authors that these widths do not give sufficient ejection clearance for the pilots wearing the large and extra large full pressure suits. However, it is believed that there should be a full range of suit-cockpit measurements to determine whether there is a "cut-off" point in pressure suit size for fitting into these two aircraft with a minimum clearance or whether the full size range can be used without creating problems with ejection procedures.

F-104A Aircraft Type C-2 Ejection Seat With D-Ring Ejection Handle

Cockpit size: Internal width

Front (near instrument panel) 24.2"
Mid (between panel and pilot) 25.2"
Rear (at the pilot's centerline) 25.7"

Subjects: Major Reynolds - extra large short suit (see Figures I-1 and I-2 of Attachment 3)

Captain Roberts - medium regular suit (see Figures I-3 and I-4 of Attachment 3)

Test Observations:

1. Seat too narrow for Major Reynolds - very doubtful if he can eject.
2. Fairly good seat for Captain Roberts.
3. Both subjects can reach all switches and knobs uninflated but mobility is limited in the inflated state.
4. The sunshade of both subjects' helmet rubbed the canopy when the canopy is closed; however, vertical seat adjustment could take care of this.
5. Most pilots wear the MC-4 partial pressure suit in this aircraft.
6. The present pilot wears K-2B flight suit and is 6'3" and weighs 240 pounds.

F-106A Aircraft (Simulator) With Armrest Ejection Handles

Cockpit size: Internal width

Front (near instrument panel) 27.3 inches

Mid (between panel and pilot) 27.7 inches

Rear (at the pilot's centerline) 27.7 inches

Subjects: Major Reynolds - extra large short FPS (see Figure I-5 of Attachment 3)

Captain Roberts - medium regular FPS (see Figures I-6 and I-7 of Attachment 3)

Test Observations:

1. There are some problems in reaching and seeing all necessary switches and knobs in the cockpit when the suit is inflated, no problems exist when the suit is uninflated.
2. Arms rub sides of cockpit when suit is inflated.
3. The knee position is close to instrument panel when suit is inflated.
4. Major Reynolds stated that he should have no problem during escape procedures (see Tables I-3 and I-4).
5. Each subject wore shoulder harness, parachute, and lap belt, but underarm preservers were not available.

ATTACHMENT 2 TO APPENDIX I

B-57D and B-57F COCKPIT COMPATIBILITY TEST

B-57 Test

The results of the evaluations in the B-57 cockpit were just the opposite to those of the fighter aircraft. The smaller subject found it somewhat difficult to reach some of the instrumentation, headrest, D-ring, etc. in the B-57 whereas in the fighter aircraft, instruments, dials, and lights were ideal for reach. Both the pilot (front) and navigator (back) seats are wider and more comfortable for both the larger or smaller aircrewmen. The following information shows the measured clearance on both sides of each seat when the suit is uninflated and inflated, the position of the pilot, and other comments.

Aircraft B-57F model internal cockpit width sill-to-sill

Pilot seat (front)	(inches)
Front (near panel)	29.2
Mid (between pilot and panel)	29.9
Back (at seat)	30.5

Navigator seat (rear)

Front (near panel)	31.0
Mid (between pilot and panel)	32.0
Back (at seat)	32.2

Aircraft B-57D model internal cockpit width sill-to-sill

Pilot seat (front)

Front (near panel)	29.2
Mid (between pilot and panel)	29.9
Back (at seat)	30.5

Navigator seat (rear)

Front (near panel)	31.0
Mid (between pilot and panel)	32.0
Back (at seat)	32.2

B-57F Tests

Subject: Major Reynolds

Suit size - extra large short

Mid cockpit clearance

Measurements - uninflated suit with vent air on, front seat

left side at elbow - 3" clearance from sill
right side at elbow - 3" clearance from sill

Measurements - inflated suit, 2.5 PSI, front seat

left side at elbow - 1.75" clearance from sill
right side at elbow - 2.25" clearance from sill

Observations:

1. Seat a little off center to the left.
2. Seat in full up position.
3. Subject can reach all necessary areas, switches, and dials in the inflated state with seat in up position.
4. Lateral vision is not too good but is not needed for these pilots.
5. Subject can reach "D" ring with both hands.
6. The pressure relief valve neither obstructs mobility or seat entry nor interferes with the lap belt or parachute harness.
7. The subject has fair mobility and will be able to eject without any interference when suit is inflated.

Measurements uninflated suit with vent air on, back seat

left side at mid shoulder - 3.4" clearance from sill
right side at mid shoulder - 5.4" clearance from sill

Observations:

1. Subject at mid cockpit with seat in the full up position.
2. The seat is off center to the left.

B-57F Tests (Contd)

Measurements - inflated suit, 2.5 PSI, back seat

left side at mid shoulder - 1.75" clearance
right side at mid shoulder - 4.3" clearance

Observations:

1. Subject can reach all necessary areas, switches, and dials in the inflated state with seat in up position.
2. Lateral vision is not good but is not needed for these pilots.

Subject: Captain J. Padget

Suit size - large long

Subject's position - ejection

Mid cockpit clearance

Measurements - uninflated suit with vent air - front seat

left side at elbow - 2.75" clearance
right side at elbow - 3.7" clearance

Measurements - inflated, 2.5 PSI, front seat

left side at elbow - 2.0" clearance
right side at elbow - 2.75" clearance

Observations: All comments are same as Major Reynolds.

Measurements - uninflated suit, with vent air, back seat

left side at mid shoulder - 4.4" clearance
right side at mid shoulder - 5.4" clearance

Measurements - inflated suit, 2.5 PSI, back seat

left side at elbow - 3.8" clearance
right side at elbow - 3.9" clearance

Observations: All comments are same as Major Reynolds.

B-57F Tests (Contd)

Subject: Captain Gary Chandler

Suit size - A/P22S-6 small short

Subject's position - ejection

Mid cockpit clearance

Measurements - uninflated suit, with vent air, front seat

left side at mid shoulder - 4.2" clearance
right side at mid shoulder - 5.3" clearance

Observations: Comments are same as for Major Reynolds.

Measurements - inflated suit, 2.5 PSI, with vent air, front seat

left side at mid shoulder - 2.65" clearance
right side at mid shoulder - 3.45" clearance

Observations:

1. All comments are same as Major Reynolds.
2. Harder to reach "D" ring in A/P22S-6 suit than in A/P22S-2 suit. (This is the usual problem with smaller suits when inflated.)

Measurements - uninflated suit, with vent air, back seat

left side at shoulder breadth - 5.0" clearance
right side at shoulder breadth - 7.2" clearance

Observations:

1. All comments are same as Major Reynolds.
2. Harder to reach "D" ring.

Measurements - inflated suit, 2.5 PSI, back seat

left side at shoulder breadth - 3.65" clearance
right side at shoulder breadth - 4.0" clearance

Observations: All comments are same as above.

B-57D Tests

Subject: Major W.W. Reynolds

Suit size: extra large short

Subject's position - ejection

Mid cockpit clearance

Measurements - uninflated suit, with vent air, front seat

left side at elbow - overlap ejection seat armrest
rest side at elbow - 1.0" clearance

Observations:

1. See information on type of ejection seat.
2. Can see and reach all pertinent instrumentation.

Measurements - inflated suit, 2.5 PSI, front seat

left side mid shoulder - arm under canopy sill
right side mid shoulder - arm under canopy sill

Observations:

1. Clearance shows almost impossible to eject safely.
2. Can see and reach all pertinent instrumentation.

Subject: Capt J. Padget

Suit size - A/P22S-6 large long

Subject's position - ejection

Mid cockpit clearance

Measurements - uninflated suit, with vent air, back seat

left side at mid shoulder - 6.25" clearance
right side at mid shoulder - 3.60" clearance

B-57D Tests (Contd)

Observations:

1. The back cockpit has been modified. All instrumentation panels have been removed and new seat installed.
2. Subject is able to see and reach all necessary equipment.
3. Ejection mechanism is at armrests.

Measurements - inflated suit, 2.5, PSI, back seat

left side at upper elbow - 2.0" clearance
right side at upper elbow - arm under canopy sill

Observations:

1. Ejection clearance is not very good.
2. Subject can see about 90° on either side.
3. Subject can reach all necessary equipment.
4. Safe ejection in the inflated state is doubtful.

Subject: Captain Gary Chandler

Suit size - A/P22S-6 small short

Subject's position - ejection

Mid cockpit clearance

Measurement - Uninflated suit, with vent air, front seat

left side mid shoulder - 5.1" clearance
right side mid shoulder - 4.9" clearance

Observations:

1. Subject can see everything except circuit breaker.
2. Subject can reach all instruments.

B-57D Tests (Contd)

3. Arms within armrests.
4. Subject can eject safely.

Measurement - inflated, 2.5 PSI, front seat

left side mid shoulder - 3.7" clearance
right side mid shoulder - 3.75" clearance

Observations:

1. Subject's arms are within armrests.
2. Visibility about 90° from center on either side.
3. Subject can reach all instruments.
4. Subject will be able to eject safely.

Measurements - uninflated suit, with vent air, back seat

left side at mid shoulder - 5.1" clearance
right side at mid shoulder - 4.9" clearance

Observations:

1. Both arms are inside armrests.
2. Subject can reach all instruments.
3. Visibility is good on all sides.
4. Subject will have no problems during ejection phase.

Measurements - inflated suit, 2.5 PSI, back seat

left side at mid shoulder - 3.7" clearance
right side at mid shoulder - 3.75" clearance

B-57D Tests (Contd)

Observations:

1. Both arms are inside armrests.
2. Visibility is good on right and left sides.
3. Subject can reach all instruments.
4. Subject will have no problems during ejection phase.

TABLE I-3

B-57 COCKPIT COMPATIBILITY TEST SUBJECTS
NUDE MEASUREMENTS (INCHES)

Subject: Captain Gary Chandler - small short suit

Shoulder breadth - standing - 18.05" (55th percentile)*
Chest breadth - standing - 11.85" (42th percentile)
Hip breadth - standing - 12.35" (11th percentile)
Chest circumference - standing - 36.2" (15th percentile)
Waist circumference - standing - 29.8" (25th percentile)
Upper thigh circumference - standing - 20.4" (13th percentile)

Subject: Major W.W. Reynolds - extra large short suit

Shoulder breadth - standing - 21.15" (99th percentile)
Chest breadth - standing - 14.1" (99th percentile)
Hip breadth - standing - 14.9" (98th percentile)
Chest circumference - standing - 42.9" (93rd percentile)
Waist circumference - standing - 39.1" (98th percentile)
Upper thigh circumference - standing - 26.6" (99th percentile)

Subject: Captain J. Padget - large long suit

Shoulder breadth - standing - 19.7" (97th percentile)
Chest breadth - standing - 12.75" (82nd percentile)
Hip breadth - standing - 14.4" (95th percentile)
Chest circumference - standing - 41.2" (84th percentile)
Waist circumference - standing - 36.4" (92nd percentile)
Upper thigh circumference - standing - 25.0" (93rd percentile)

*H. T. E. Hertzberg, et al. Anthropometry of Flying Personnel - 1950.
WADC-TR-52-321 (AD 47953). Wright Air Development Center,
Wright-Patterson AFB, Ohio. 1954.

TABLE I-4

B-57 COCKPIT COMPATIBILITY TESTS

Subjects in suits with parachute harness and underarm life preserver; suit inflated to 2.5 PSI

Major Reynolds

Chest (axillary) depth - 14.5" (across tiedown) (13.7" under tiedown)
Shoulder breadth - 27.4"

Captain Padget

Axillary chest depth - 14.1" under tiedown
Shoulder breadth - 27.1"

Captain Chandler

Axillary chest depth - 12.0" under tiedown
Shoulder breadth - 24.85"

ASD-TR-70-25

ATTACHMENT 3 TO APPENDIX I

ILLUSTRATIONS

Figures I-1 through I-7



Figure I-1. View Showing Canopy Sill Clearance - F-104A Aircraft,
Large A/P22S-6 Suit (Uninflated) - Major Williams Reynolds



Figure I-2. View Showing Canopy Sill Clearance - F-104A Aircraft,
Large A/P22S-6 Suit (Inflated to 2.5 PSI) -
Major William Reynolds



Figure I-3. View Showing Canopy Sill Clearance and Instrument Panel Reach - F-104A Aircraft, Medium A/P22S-6 Suit (Uninflated) - Captain Paul F. Roberts

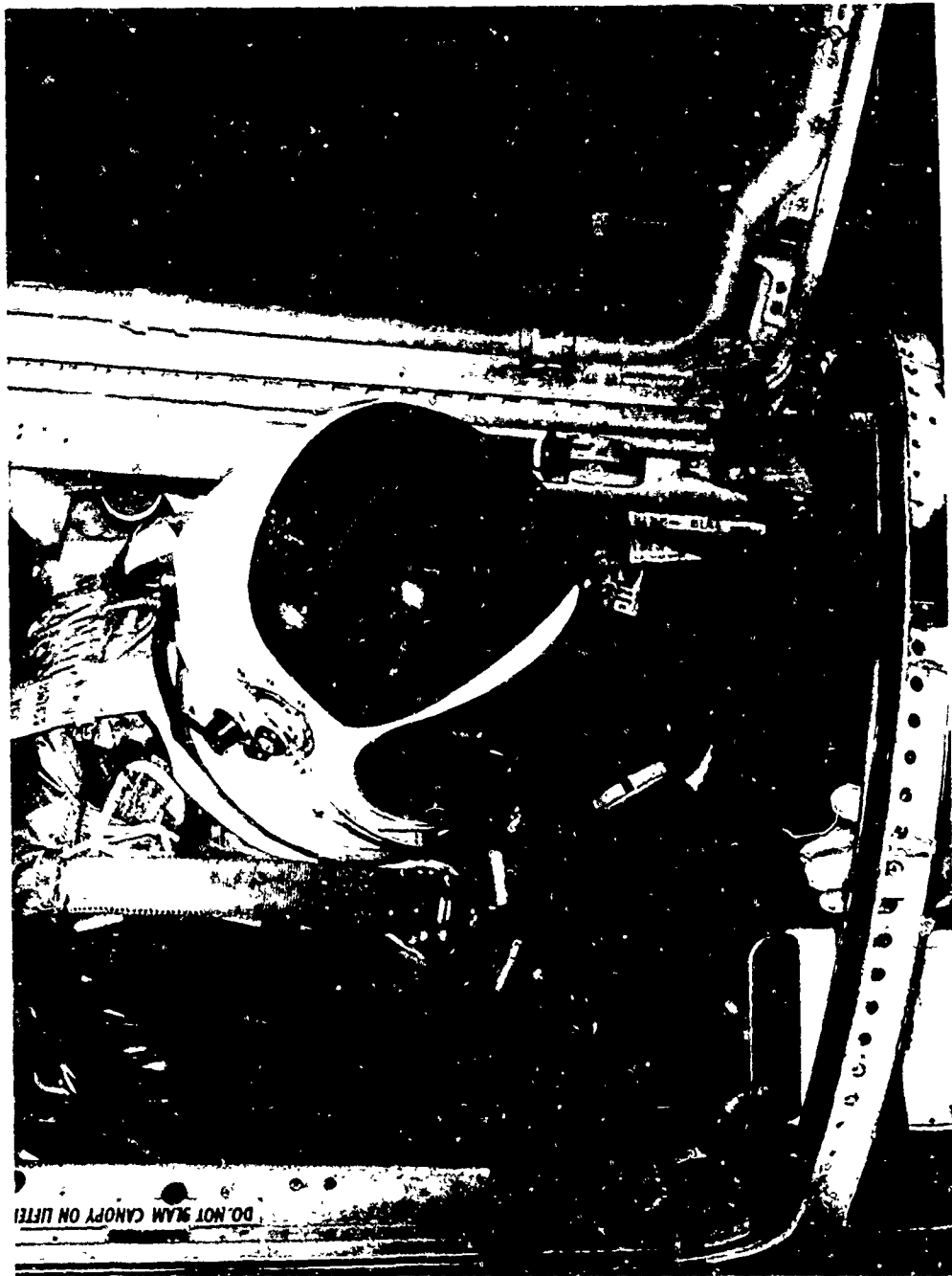


Figure I-4. View Showing Canopy Sill Clearance - F-104A Aircraft,
Medium A/P22S-6 Suit (Inflated to 2.5 PSI)
Captain Paul F. Roberts

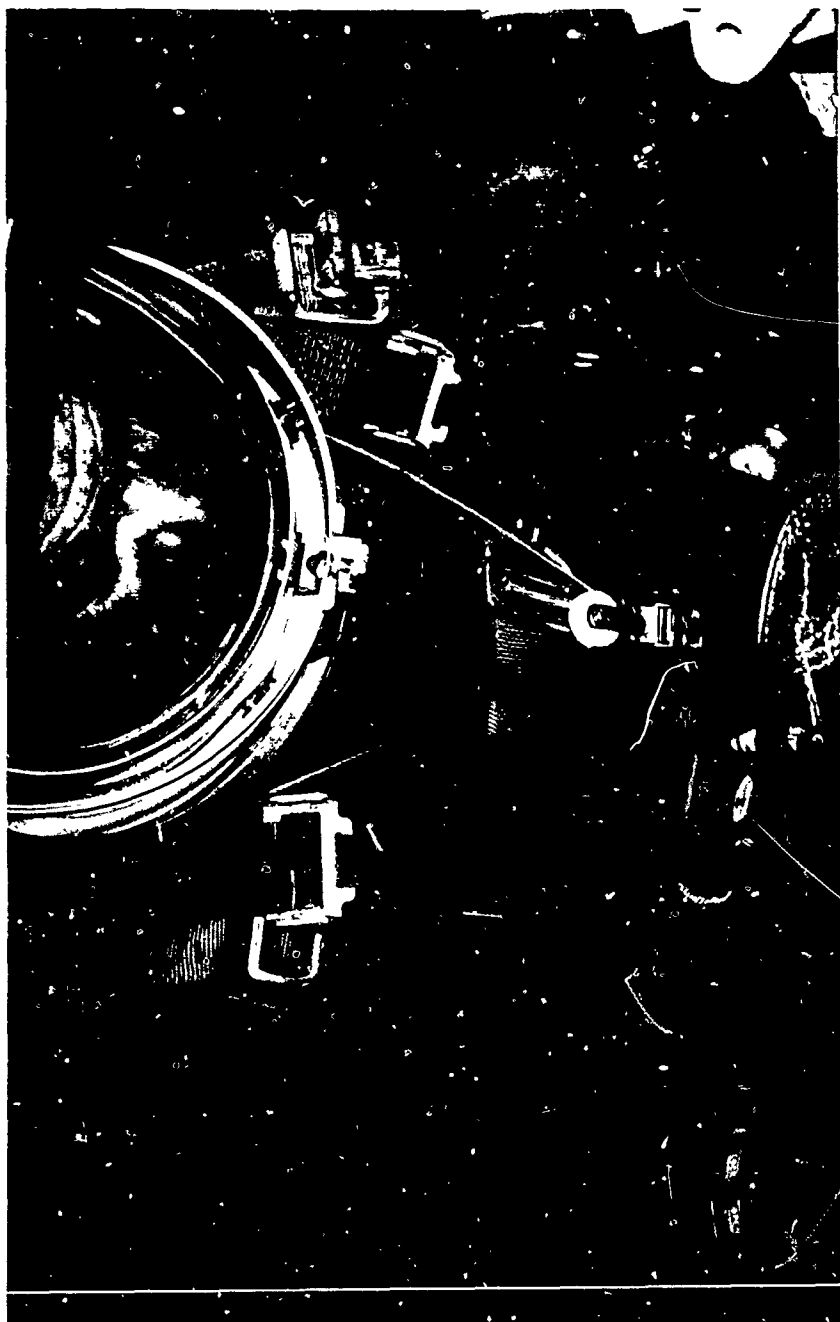


Figure I-5. View Showing Canopy Sill Clearance - F-106A Aircraft,
Large A/P22S-6 Suit (Inflated to 2.5 PSI) -
Major William Reynolds



Figure I-6. View Showing Canopy Sill Clearance and Control Stick Access - F-106A Aircraft, Medium A/P22S-6 Suit (Inflated to 2.5 PSI) Captain Paul F. Roberts



Figure I-7. View Showing Canopy Sill Clearance and Ejection Handle Access - F-106A Aircraft, Medium A/P22S-6 Suit (Inflated to 2.5 PSI) - Captain Paul F. Roberts

ATTACHMENT 4 TO APPENDIX I

PERSONS CONTACTED AT TYNDALL AND KIRTLAND AFBS.

*Major C. R. Cooley, Cmdr 56 PTF FPS Depot, Tyndall AFB
*Captain P. R. Roberts OIC FPS Depot, 56 PTF, Tyndall AFB
*CMSgt W. F. Thomas, Auditor General Staff Auditor, Tyndall AFB
TSgt M. K. McCall, FPS Tech, 4756 PTF, Tyndall AFB
TSgt G. Lokatos, FPS Tech, 4756 PTF, Tyndall AFB
Sgt M. P. Flannery, FPS Tech, 4756 PTF, Tyndall AFB
*Major W. W. Reynolds, Life Support Officer, 58 WRS, Kirtland AFB
*SMSgt J. R. Penz, Life Support, 58 WRS, Kirtland AFB
*MSgt G. T. Davidson, Life Support, 58 WRS, Kirtland AFB
*Major C. L. Brown, OIC, 4780 PTF, Perrin AFB
*TSgt D. R. G'asson, 4780 PTF, Perrin AFB
*Major H. J. Caldwell, Life Support Office, 4677 DSES (ADC) Hill AFB
*Major C. A. Lehman, Asst Life Support Officer, ADC
*MSgt D. T. Gween, Life Support Supt, LEMO, ADC
*Captain D. R. Talbott, Asst Life Support Officer, MAC, Scott AFB
*Mr. A. Albr'ght, Pressure Outfit Mgr, SAAMA (SANDRA), Kelly AFB
*Mr. K. F. Troup, Program Manager, ASWLN, WPAFB
Mr. J. Henrickson, Project Monitor, David Clark Company (DCC),
Worcester, Mass
Mr. P. Crane, Sales Engineer, Scott Aviation, Lancaster, New York
Mr. D. Wohlgemuth, Mgr R&E, International Latex Corp., Dover, Dela

and other personnel from the 4856th PTF, Tyndall AFB and the 58 WRS,
Kirtland AFB.

*Attended Integration Meeting at Tyndall AFB, Florida.

ASD-TR-70-25

APPENDIX II

COMPATIBILITY TESTS OF A/P22S-2 AND A/P22S-6 IN COCKPIT OF B-57D AIRCRAFT

Tests conducted at 4677th DSES, Hill AFB, Utah

February 1969

1. GENERAL DISCUSSION

a. The test conditions, or ground rules, were formulated by ASD, AMD, and 4677th DSES personnel at a meeting held on 25 Feb 69 at Hill AFB, Utah, and were as follows:

(1) Each subject would wear the LPU-2/P underarm life preservers. Major Caldwell and Captain Needels were insistent on their use since all squadron flights in which pressure outfits are worn present water hazards. Inland lakes were also a matter of concern.

(2) The outfits were to be inflated to between 2.8 (70,000 ft) and 3.0 PSI (80,000 ft). Actual pressures in the outfits during the test ranged from 2.75 to 3.5 PSI. Exact readings of the gauge were difficult due to minor surges of pressure, respiration, and body movement.

(3) During normal ejection procedures, the subjects' elbows should be in the armrests, inside the armrest guards. This elbow-arm positioning would assure safe clearance through the canopy sills and is in accordance with procedures in the B-57D operational handbooks. However, it was soon determined that placing the elbows fully into the armrests, inside the armrest guards in the B-57D seat, was difficult even without a pressure outfit due to the height of the survival seat kit, seat type parachute, and the thickness of the liferaft on the pilot's back and also the elbow rests being too low for personnel with shorter shoulder-to-elbow lengths.

(4) Each subject participating in the test would wear a full set of gear which included:

LPU-2/P Underarm Life Preservers
CNU-7/P Back Type Life Raft
F1121500-4 Seat-Type Survival Kit
SA-20 Seat Type Parachute

b. The critical dimensions of the B-57D cockpit and seats were measured and are recorded in Table II-1. The nude dimensions of selected test subjects were measured and are recorded in Table II-2.

TABLE II-1
LATERAL DIMENSIONS OF B-57D AIRCRAFT

Front Cockpit

Canopy sill-to-canopy sill

Fore: 29.3 inches

Middle: 30.3 inches

Aft: 30.3 inches

Outer lip of left armrest to outer lip of right armrest = 24.7 inches

Clearance between outer lip of armrest and canopy sill

Right: 3.0 inches

Left: 2.4 inches

Rear Cockpit

Canopy sill-to-canopy sill

Fore: 31.1 inches

Middle: 32.5 inches

Aft: 32.2 inches

Outer lip of armrest to outer lip of armrest = 24.0 inches

Clearance between outer lip of armrest and canopy sill

Right: 4.45 inches

Left: 4.1 inches

TABLE II - 2
NUDE DIMENSIONS OF SELECTED SUBJECTS

Dimensions	Capt Lucas		Sgt Andrews		Capt Needels	
	Inches	Percentile*	Inches	Percentile*	Inches	Percentile*
Shoulder Breadth	21.6	99+	20.1	99	18.55	75
Chest Breadth	15.1	99+	13.45	95	12.75	80
Waist Breadth	14.95	99+	12.55	96	11.5	82
Elbow-to-Elbow Breadth	24.5	99+	20.7	98	18.85	85
Chest Depth	11.0	99	9.0	50	9.05	50
Waist Depth	11.2	99+	8.75	80	8.55	75
Height	67.1	20	76.35	99+	69.65	60
Chest Circumference	44.3	98	39.0	55	37.1	25
Waist Circumference	42.5	99+	34.1	75	34.0	75
Shoulder Circumference	52.7	99+	47.6	85	45.0	50
Weight	220 lbs	99+	201 lbs	95	168 lbs	60
*H. T. E. Hertzgerg, et al. <u>Anthropometry of Flying Personnel - 1950</u> . WADC-TR-52-321 (AD 47953). Wright Air Development Center, Wright-Patterson AFB, Ohio. 1954.						

c. The actual testing of the subjects in seat positions was conducted and photographed as follows:

(1) Suited subject donned personal protective equipment and entered front seat of aircraft

(2) Figures II-1 and II-2 of Attachment 1 show the subject in aircraft, wearing a K2B flight suit and jacket and can be compared with Figure II-3 showing the subject in the A/P22S-2 outfit with the positioning of the arms and elbows during ejection phase without pressure. These two conditions can be compared with the same subject in the A/P22S-2 suit in Figure II-4 with the suit in the pressurized state.

(3) Figure II-5 shows Captain Lucas in the A/P22S-6 FPS with no pressure, and Figure II-6 shows him in the same suit with pressure.

Observations can be made in regard to positioning of the arms, elbows, and shoulders in these sequences. See Table II-2 for subject's nude size.

Captain Needels, who weighs 167 pounds, is shown wearing the medium long A/P22S-2 outfit in Figure II-7, with no pressure. This figure can be compared with Figure II-8 while the outfit is pressurized. Special attention should be given to these figures because of the precise breadths of elbow-to-elbow and shoulder while the subject is in the ejection phase and pressurized. Note the distance between headrest and helmet.

(5) Figure II-9 shows Captain Needels wearing the small regular A/P22S-6 outfit in the uninflated state. This is a downgrade from the indicated size of medium long in the A/P22S-2 outfit. Note the arm, elbow, and shoulder positions in Figure II-10 when the outfit is inflated. Also note the backward reach in Figure II-11 at a suit pressure of 3 PSI.

(6) With all subjects wearing both types of outfits, the seat was raised to positions where elbows were at level of canopy sills. The figures show a comparative difference in elbow-to-elbow and shoulder breadth of each subject in the uninflated and inflated state and the space advantage the smaller suits have over the large and extra large suits.

e. The results and full nomenclature of each subject measured and tested are noted in Table II-3.

2. CONCLUSIONS

a. Front seat of B-57D aircraft - subject wearing A/P22S-2 outfit

(1) The subjects (200 pounds or over) wearing the uninflated extra large size A/P22S-2 outfit could clear the canopy sills when the seat was raised under a 1-g situation. However, when the suit was inflated to 2.75-3.0 PSI, considerable contact of the elbows of the suit with the canopy sills was evident. A potentially hazardous condition may exist when a pilot wearing this size suit actually ejects under a 15-g ejection acceleration since the elbows may "jam" under the canopy sills and result in damage to the elbows or tearing of the suit.

(2) Subjects who weighed less than 200 pounds and wore smaller sizes of the A/P22S-2 outfit (large: under 200 pounds, medium: under 175 pounds,

TABLE II - 3
COCKPIT COMPATIBILITY TEST OF THE A/P22S-2 AND A/P22S-6 OUTFITS IN THE B-57D AIRCRAFT
25-27 FEBRUARY 1969

Test No.	Subject's Name	Outfit and Coverall (Size)	Seat* Position	Elbow Clearance (inches)		Elbows in Armrest	Head in Headrest	Seat and Reach All Necessary Controls	Outfit Pressure (PSI)	Subject Tested in Seat		Comments
				Left	Right					Front	Back	
1	Lucas	K2B S Winter Fit Jacket	down	2.5	2.8	bone only	yes	yes	—	X		Arms not in armrests without pressure suit.
2	Lucas	K2B S Winter Fit Jacket	up	2.4	2.0	bone only	yes	yes	—	X		Arms not in armrests without pressure suit.
3	Andrews	S-2 LL	up	2.85	2.75	yes	no	yes	0	X		
4	Andrews	S-2 LL	up/down	—	—	no on right (rubs) yes on left barely	no	no**	2.75	X		
5	Lucas	S-2 XLR	up/down	—	—	no	no	yes	0	X		Would like to see a handle at forward part of cockpit to help movement to reach cockpit areas otherwise inaccessible.
6	Lucas	S-2 XLR	up/down	—	—	no	no	no**	2.75	X		Clearance marginal.
7	Lucas	S-2 XLR	up/down	—	—	no	no	no**	3.5	X		Would not care to fly S-6 in this size because right elbow bone rubs canopy rail.
8	Lucas	S-6 LS	up/down	—	—	bone only	no	yes	0	X		
9	Lucas	S-6 LS	up/down	—	—	no	no	no**	2.75	X		
10	Lucas	S-6 LS	down	—	—	no	no	no**	2.75	X	X	
11	Needels	S-2 ML	up	—	—	yes	yes	yes	0	X		
12	Needels	S-2 ML	up	2.3	0.5	yes	yes	no**	2.75	X		
13	Needels	S-2 ML	up	—	—	yes	no	no**	3.5	X		
14	Needels	S-2 ML	down	—	—	yes on left no on right	no	no**	3.5	X	X	
15	Andrews	S-6 LL	up	—	—	yes	yes	yes	0	X		
16	Andrews	S-6 LL	up	2.0	0	no	no	no**	2.75	X		Hole in right glove made pressurization difficult.
17	Andrews	S-6 LL	up	—	—	no	no	no**	2.75	X	X	
18	Brumit	S-2 LL	up	—	—	yes	yes	yes	0	X		
19	Brumit	S-2 LL	up	—	—	no	no	no**	2.75	X		
20	Steady	S-2 ML	up	—	—	yes	yes	yes	0	X		
21	Steady	S-2 ML	up	—	—	yes on left no on right (rubs)	no	no**	2.75	X		
22	Needels	S-6 SR	up	—	—	yes	no	yes	0	X		
23	Needels	S-6 SR	up	—	—	yes	no	no**	2.75	X		
24	Von Wolffradt	S-2 LR	up	—	—	yes (with effort)	no	yes	0	X		
25	Von Wolffradt	S-2 LR	up	—	—	no	no	no**	2.75	X		
26	Rice	S-6 LS	up	—	—	yes (bones or'y)	no	yes	0	X		
27	Rice	S-6 LS	up/down	—	—	no	no	no**	2.75	X	X	
28	Rice	S-6 LS	up/down	—	—	no	no	no**	3.5	X		
29	Von Wolffradt	S-6 MS	up/down	—	—	yes	no	yes	0	X		
30	Von Wolffradt	S-6 MS	up	—	—	no	no	no**	2.75	X	X	Even without pressure suit, he sits high in seat due to seat contents and cannot get arms in rests. He uses guards as a rest.

* Seat Position - up with elbow at rail or down with elbow below rail.

** No, couldn't see beyond 90° from straight ahead at either side but can reach and touch.

and small: under 150 pounds) were capable of passing through the escape envelope (canopy sills) with little or no rubbing of the elbows in both the uninflated and inflated (2.75 to 3.0 PSI) condition.

b. Rear seat of B-57D aircraft - subject wearing A/P22S-2 outfit - All subjects could clear the escape envelope (canopy sills) when the A/P22S-2 outfit was uninflated and inflated to 3.5 PSI, although the over 200-pound man could not place his elbows fully into the armrests. The lateral distance of canopy sill-to-canopy sill at the rear of the B-57D aircraft cockpit is somewhat larger than the front and subsequently does not present as critical a clearance problem for the pilot as the front cockpit.

c. Front seat of B-57D aircraft - subject wearing A/P22S-6 outfit - The extra large size of the A/P22S-6 outfit should not be used in this aircraft in either the front or rear seat since the ballooning of the suit presents hazardous clearance problems. The subjects (200 pounds or over) wearing the uninflated large size could clear the canopy sills when the seat was raised under a 1-g condition. However, when the suit was inflated to 2.75-3.0 PSI, considerable contact of the elbows of the suit with the canopy sills was evident. A potentially hazardous condition may exist when a pilot wearing this size suit actually ejects under a 15-g ejection acceleration since the elbows may "jam" under the canopy sills and result in injury to the elbows or tearing of the coverall. (Note: The A/P22S-6 outfit coverall is sized larger than the A/P22S-2 outfit coverall, therefore, coverall sizes must be downgraded.) Subjects who weighed less than 200 pounds and wore smaller sizes of the A/P22S-6 coverall (medium: 200 pounds, small: under 175 pounds) were capable of passing through the escape envelope (canopy sills) with little or no interference to the elbows in both the uninflated and inflated (2.75-3.0 PSI) conditions.

d. Rear seat of B-57D aircraft - subject wearing the A/P22S-6 outfit - All subjects wearing the large, medium, and small A/P22S-6 outfit coverall could clear the canopy sills with the outfit uninflated and inflated to 3.5 PSI, although the over 200-pound man could not place his elbows fully into the armrests. The lateral distance of canopy sill-to-canopy sill in the rear seat of this aircraft is somewhat larger than the front seat and does not present as critical a clearance problem for the pilot as the front seat.

e. Other considerations for both A/P22S-2 and A/P22S-6 outfits in both rear and front seats

(1) The ability of the pilots to assume a correct ejection position in rapid time is questionable due to the bulkiness of the pressure outfit and the "blocking" effect of the LPU-2/P underarm life preservers.

(2) The back-type life raft and ballooning of the rear torso of the suit when inflated prevents the pilot from placing his head against the headrest of the seat. This could result in spinal misalignment with the trajectory of the ejecting seat and possibly result in injury.

(3) The height of the armrest (thickness of the seat cushion) and the "pushing-forward" effect of the back-type life raft prevents a pilot of any size from placing his elbows securely in the armrests of the seat and may result in injury.

(4) In general, the inflated pressure-suited subject has difficulty in viewing and reaching any switches or handles beyond 90° to either side.

(5) The ideal body position is with the body centerline in line with the seat centerline. This is difficult for the aircrew member to determine in the suited condition. If this does not occur, the possibility of catching one arm under the sill is quite apparent.

(6) The use of the A/P22S-2 and A/P22S-6 outfits in the B-57D aircraft with ejection seat armrest handles causes the elbow-to-elbow breadth to be a maximum during the ejection activation mode due to arm positioning. Use of these outfits in the B-57D aircraft which includes an ejection seat (Escape Pac 1C6) with a D-ring between the legs allows the elbow-to-elbow breadth to be minimal due to the arm position, during the ejection activation mode, being in front of the underarm life preservers. The minimal breadth is desirable particularly on the extra large man.

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ATTACHMENT I TO APPENDIX II

ILLUSTRATIONS

(Figures II-1 through II-11)



Figure II-1. View Showing Canopy Sill Clearance in Ejection Position - B-57D Aircraft, X-Large K-2B Flight Suit and Jacket



Figure II-2. View Showing Clearance During Ejection - B-57D Aircraft,
X-Large K-2B Flight Suit and Jacket

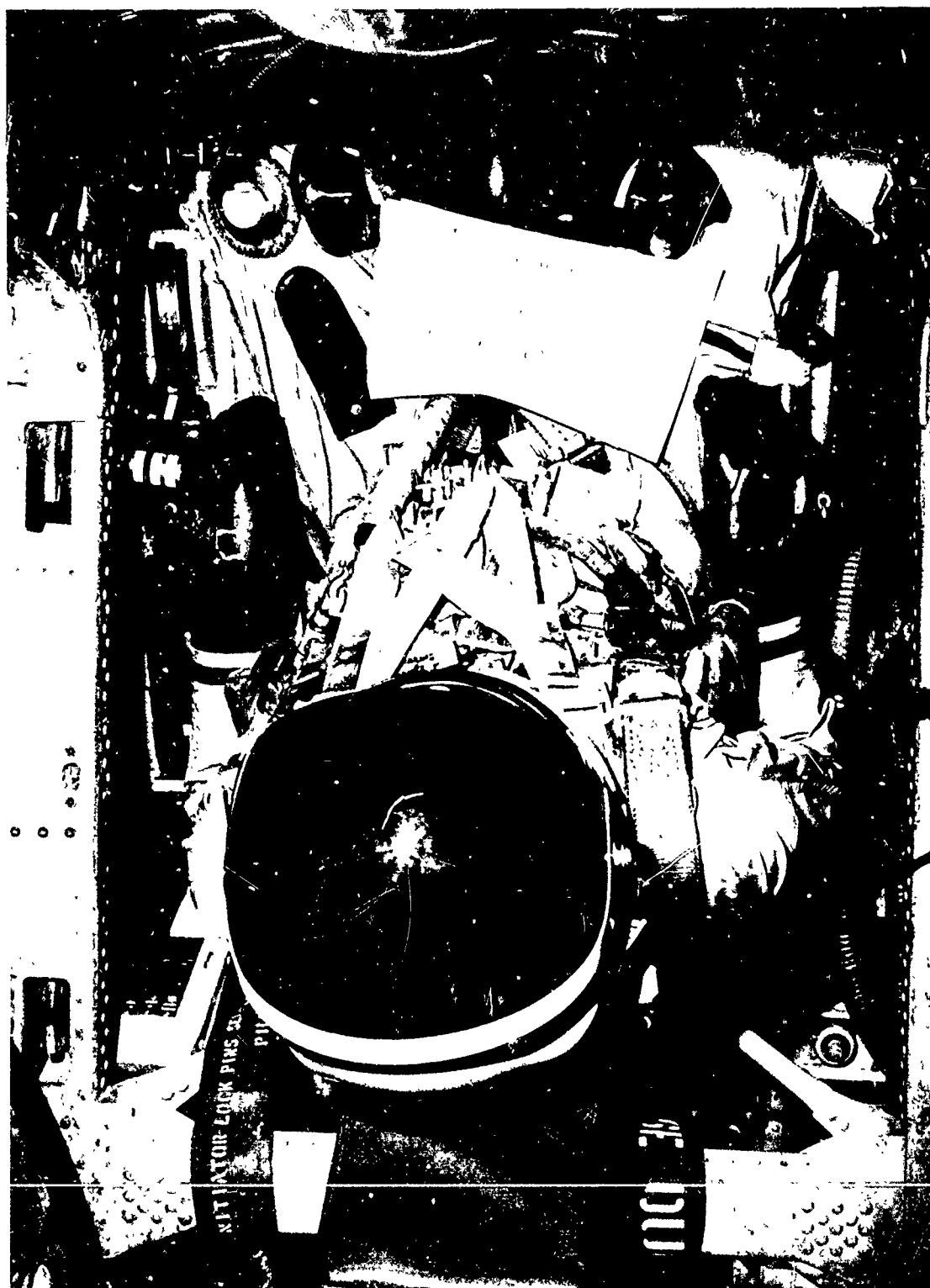


Figure II-3. View Showing Canopy Sill Clearance - B-57D Aircraft,
X-Large A/P22S-2 Suit (Uninflated)

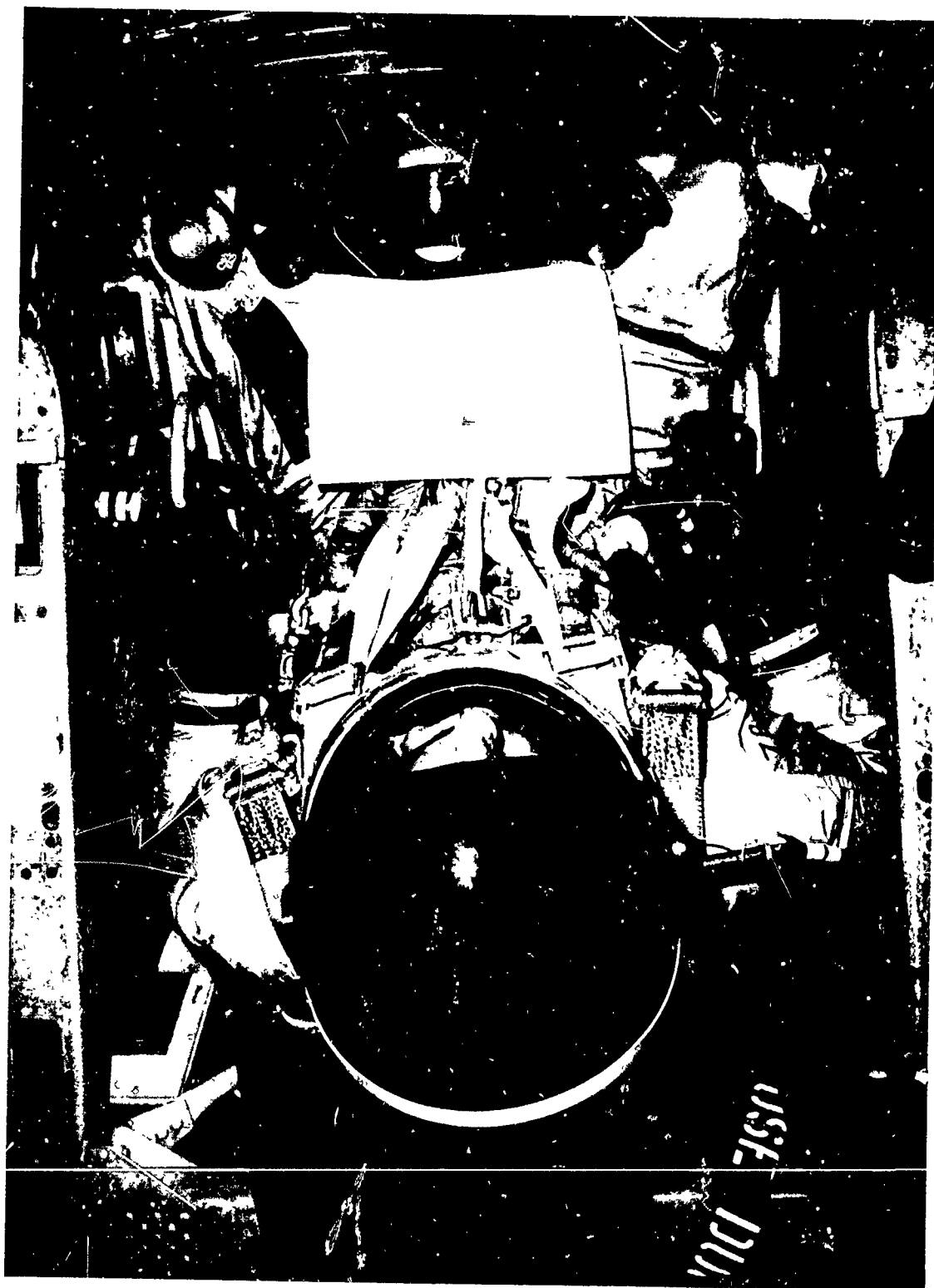


Figure II-4. View Showing Canopy Sill Clearance and Ejection Handle Access - B-57D Aircraft, Extra Large A/P22S-2 Suit (Inflated to 2.75 PSI)

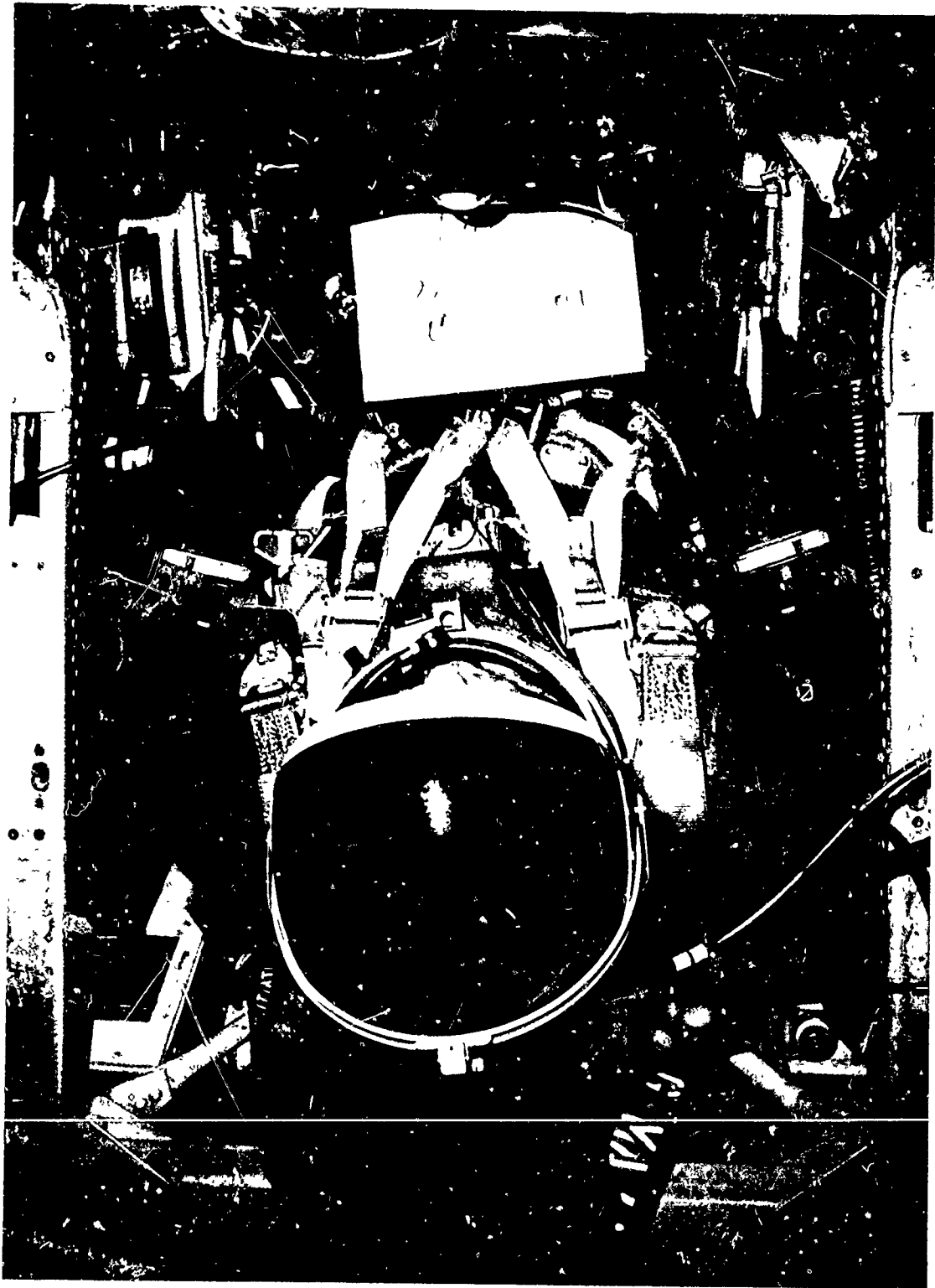


Figure II-5. View Showing Canopy Sill Clearance and Ejection Handle Access - B-57D Aircraft, Extra Large A/P22S-6 Suit (Uninflated)

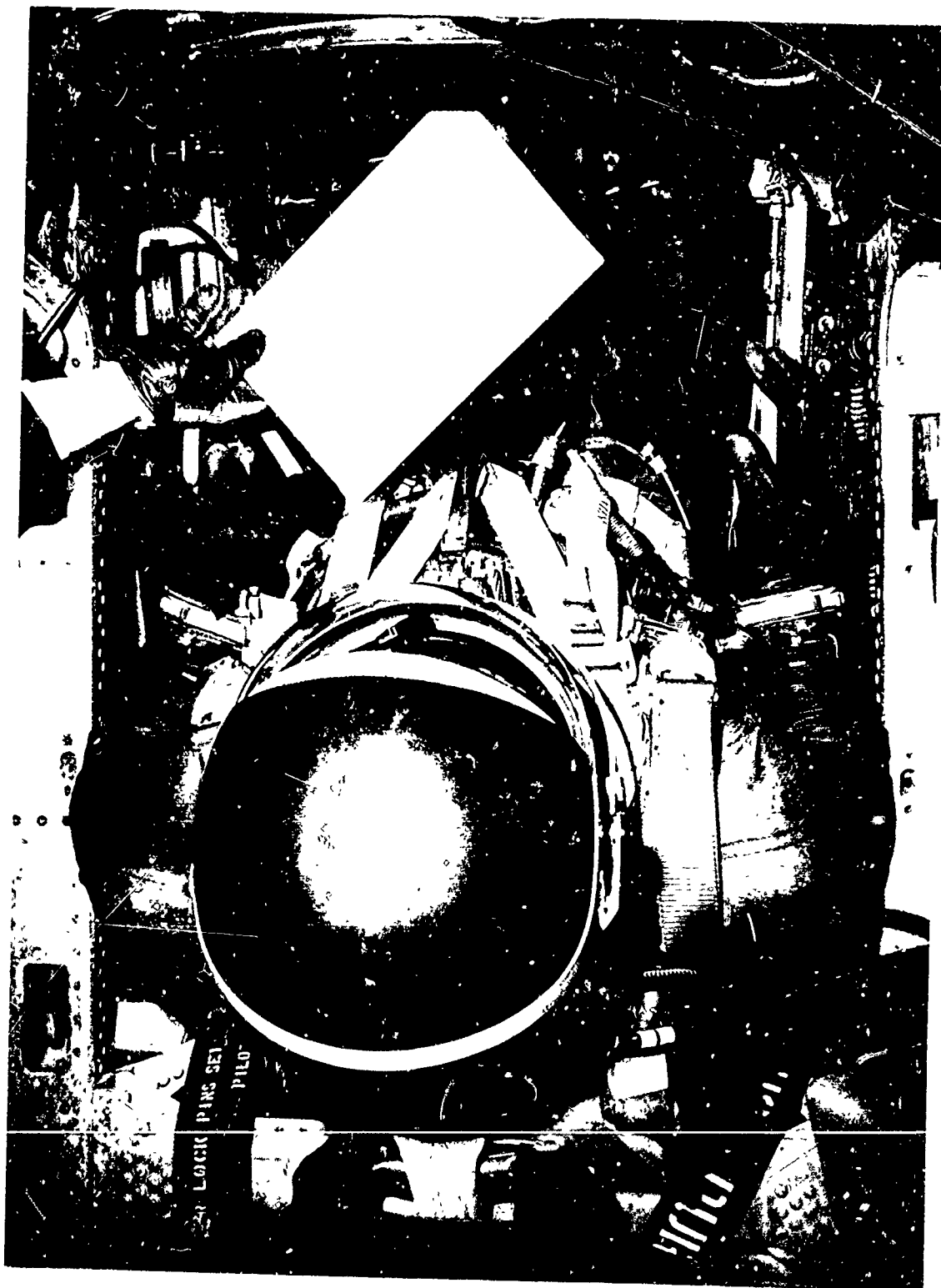


Figure II-6. View Showing Canopy Sill Clearance and Ejection Handle Access - B-57D Aircraft, Extra Large A/P22S-6 Suit (Inflated to 2.75 PSI)



Figure II-7. View Showing Canopy Sill Clearance and Ejection Handle Access - B-57D Aircraft, Medium Long A/P22S-2 Suit (Uninflated)

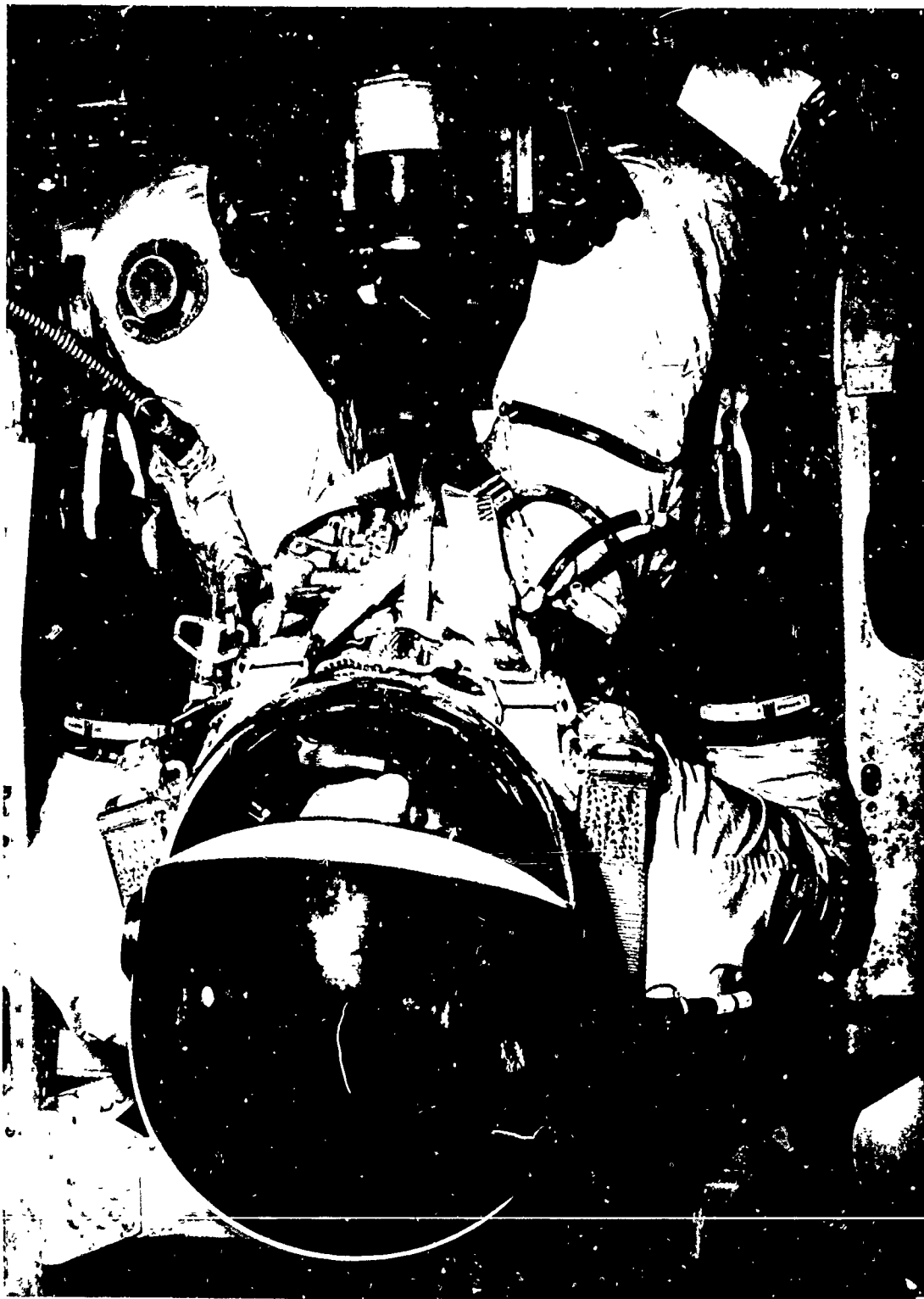


Figure II-8. View Showing Canopy Sill Clearance and Ejection Handle Access - B-57D Aircraft, Medium Long A/P22S-2 Suit (Inflated to 3.5 PSI)

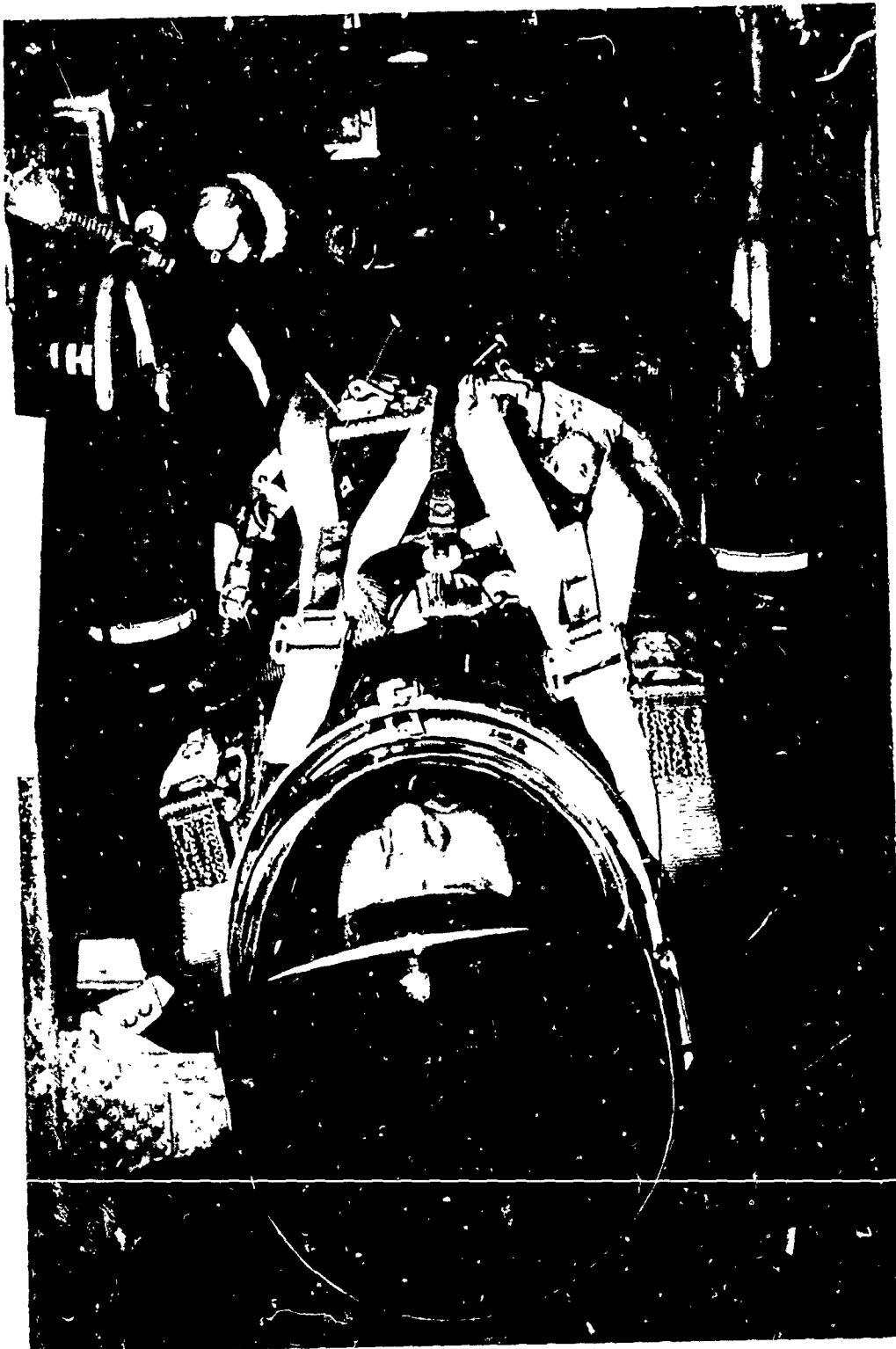


Figure II-9. View Showing Canopy Sill Clearance and Ejection Handle Access - B-57D Aircraft, Small Regular A/P22S-6 Suit (Uninflated)

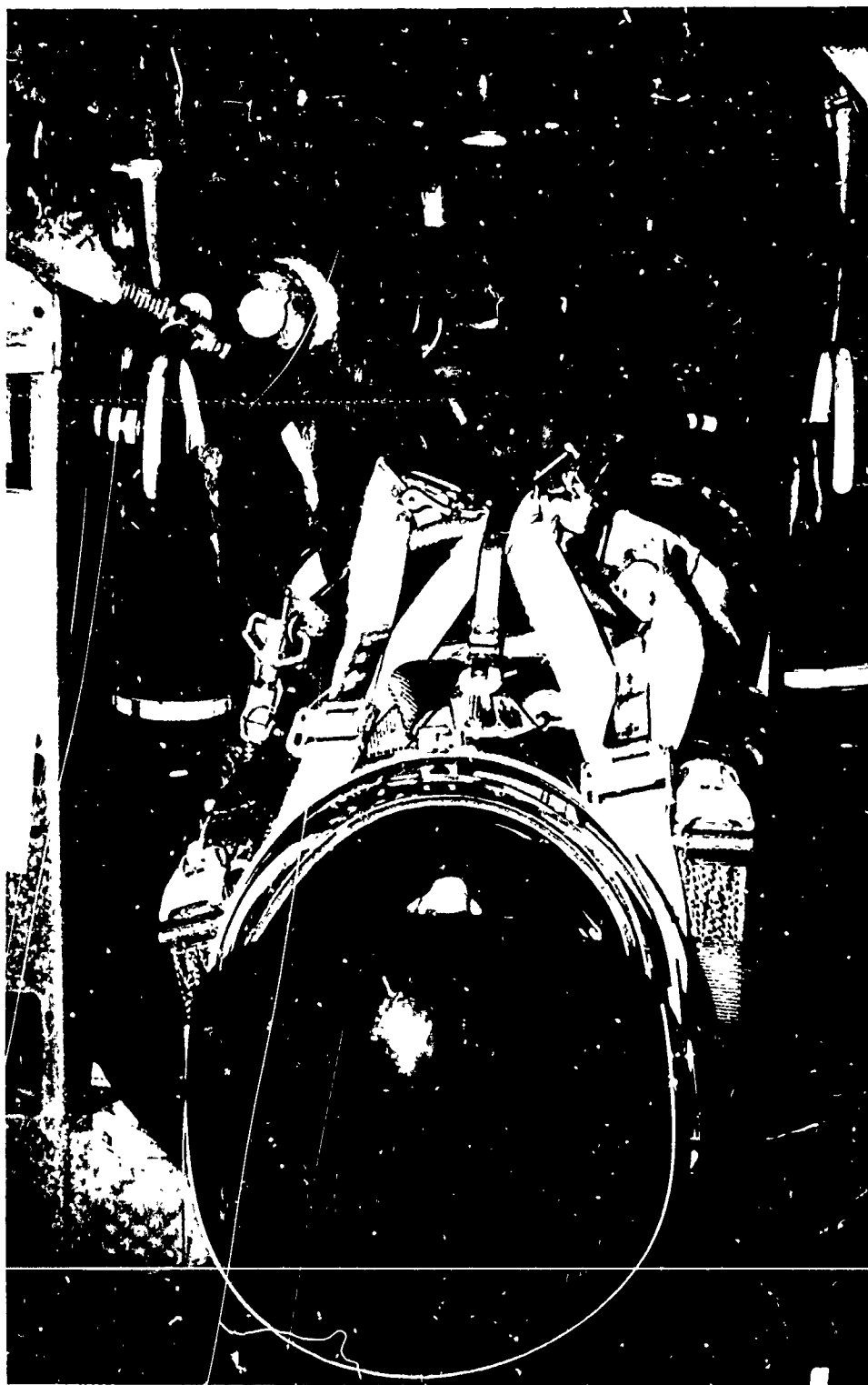


Figure II-10. View Showing Canopy Sill Clearance and Ejection Handle Access - B-57D Aircraft, Small Regular A/P22S-6 Suit (Inflated to 2.75-3.0 PSI)



Figure II-11. View Showing Backward Reach - B-57D Aircraft,
Small Regular A/P22S-2 Suit (Inflated to 2.75 to 3.0 PSI)

ATTACHMENT 2 TO APPENDIX II

PERSONS CONTACTED AT Hill AFB, UTAH

Major Caldwell, Life Support Officer, 4677th DSES

Captain Needels, Asst Life Support Officer, 4677th DESs

Captain Lucas, Pilot

Major Von Wolfradt, Pilot

T/Sgt Winnett, NCOIC of the Life Support Section and other
personnel of the 4677th DSES

Captain Roberts, CO pressure Suit Depot, Tyndall AFB, (4756th PTF)

T/Sgt Blackburn, 4756th PTF

T/Sgt Dutka, 4756th PTF

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APPENDIX III

COMPATIBILITY TESTS OF A/P22S-2 AND
A/P22S-6 IN COCKPITS OF F-104B AND
F-106B AIRCRAFT

Tests conducted at 4756th USAF Hospital (56th PTF)
Tyndall AFB, Florida

September 1969

1. GENERAL DISCUSSION

a. Both the A/P22S-2 and A/P22S-6 outfits were tested in the uninflated and inflated state in the F-104B and F-106B aircraft. Each subject participating in the tests wore the following personal equipment in addition to the pressure suits: LPU-3/P underarm life preservers (F-104B and F-106B), B-5 parachute (F-104B) and BA-22 parachute (F-106B).

b. The outfits were inflated to 3.5 PSI (equivalent to 100,000 feet and above). During emergency ejection procedures (uninflated and inflated suit), it was requested that the subject's elbows be placed in the arm rests inside the elbow guards in the F-106B aircraft seat. In the F-106B aircraft seat, the positioning of the elbow-arm should allow sufficient clearance, during the ejection phase, through the canopy sills in accordance with procedures in the F-104B and F-106B operational handbooks. With the outfit in the inflated state in the F-106B, the ability of the wearer to place the elbows into the armrest and inside the elbow guards is limited. This is especially apparent when the large and extra large A/P22-6 suits are used. The wearer's ability to reach the D-ring in the F-104B aircraft ejection seat depends upon the height of the survival seat kit and the shoulder-to-elbow length and elbow-to-elbow breadth. The shortness of the shoulder-to-elbow usually occurs with the persons who are short in stature.

c. Tests began with the cockpit seat in the down position and the reach envelope (to operate essential cockpit instruments) was obtained in that position, in the mid-raised position of the seat and when the seat was fully raised. The fully raised position of the seat in the F-104B was limited to about three-fourths of its maximum height due to bolts on the ejection rails. In the F-106B, the fully raised position was such that the elbows were above the canopy sills. Also measured in these positions were the elbow-to-canopy sill clearance, head position in regard to headrest, knee and leg positions, and the location of the arms. The angle of seat ejection (from the vertical plane) in both the F-104B and F-106B is about 13°.

d. Reference is made to pages 64 through 67 of AMRL-TR-69-6 which show anthropometric measurements of the maximum thigh-to-thigh breadth, knee-to-knee breadth, elbow-to-elbow breadth, and maximum hand-to-hand breadth. All measurements are accomplished with the subjects in the sitting

position and the pressure suit in the uninflated state. A comparative analysis of these measurements can be made in regard to those of the aircraft cockpit. It is only in the inflated state (3.5 PSIG), sitting in the ejection seat, in the classical position, with the parachute and LPU-3/P life preserver that excessive measurements (ballooning) occur. This is the only position that will indicate that most of the pressure suit measurements are greater than the cockpit measurements of both the F-104B or F-106B aircraft. The maximum elbow-to-elbow breadth in any pressure suit uninflated is 23.9 inches. The minimum width inside dimensions of the front canopy sill-to-canopy sill cockpit of the F-106B and F-104B aircraft are 27.75 and 26.5 inches, respectively. Ejection procedures can be initiated with very little difficulty. The F-106B aircraft cockpit is larger than that of the F-104B cockpit and the air egress procedures differ in the two types of aircraft. The F-106B has the seat arm triggering device and the F-104B uses the D-ring. The seat arm trigger permits the arm-elbow area of the pilot to extend toward the canopy sill (classical position) whereas the D-ring position allows the arm-elbow to extend at an angle to the center between the legs. If the pressure suit during inflation grows (balloons) excessively, the problem of escape in both aircraft becomes greater. It should be noted that there are very few pilots who have ejected from an aircraft in an inflated pressure suit.

e. The critical dimensions of the cockpit and seat were measured and are reported in Tables III-1, III-2, and III-3. The nude dimensions of the selected subjects were measured and are recorded in Table III-4.

f. The seat designations in the F-104B and F-106B aircraft follows:

- (1) For F-104B -
 P/N 803498-417
 Seat A/C Ejection Upward
 T. O. 13A5-18-84
 Mfg: Weber
- (2) For F-106B -
 Type C-2 Seat
 T. O. 13A5-24-3
 Mfg: Stanley and Lockheed

TABLE III-1
LATERAL DIMENSIONS OF F-104B AIRCRAFT

Front Cockpit

Canopy sill-to-canopy sill

Fore: 24.25 inches

Middle: 26.0 inches

Aft: 26.5 inches

Outer lip of left armrest to outer lip of right armrest

Armrest - not applicable

Clearances between outer lip of armrest and canopy sill

Right - not applicable

Left - not applicable

Rear Cockpit

Canopy sill-to-canopy sill

Fore: 27.0 inches

Middle: 26.25 inches

Aft: 24.25 inches

Outer lip of armrest to outer lip of armrest - not applicable

Clearance between outer lip of armrest and canopy sill

Right: not applicable

Left: not applicable

F-104B and F-104A - have same cockpit area size.

TABLE III-2
LATERAL DIMENSIONS OF F-106B AIRCRAFT

Front Cockpit

Canopy sill-to-canopy sill

Fore: 27.75 inches

Middle: 28.35 inches

Aft: 28.75 inches

Outer lip of left armrest to outer lip of right armrest

Armrest - not applicable

Clearance between outer lip of armrest and canopy sill

Right - not applicable

Left - not applicable

Rear Cockpit

Canopy sill-to-canopy sill

Fore: 28.75 inches

Middle: 27.75 inches

Aft: 26.25 inches

Outer lip of armrest to outer lip of armrest - not applicable

Clearance between outer lip of armrest and canopy sill

Right: 2.2 inches

Left: 2.2 inches

TABLE III-3

LATERAL DIMENSIONS OF F-106A ONE SEATER AIRCRAFT
(Same Seat and Same Ejection as F-106B)

Front Cockpit

Canopy sill-to-canopy sill

Fore: 27.75 inches

Middle: 28.0 inches

Aft: 27.7 inches

Outer lip of left armrest to outer lip of right armrest

Armrest - not applicable

Clearance between outer lip of armrest and canopy sill

Right - not applicable

Left - not applicable

Rear Cockpit

Canopy sill-to-canopy sill

Fore: not applicable

Middle: not applicable

Aft: not applicable

Outer lip of armrest to outer lip of armrest -

Clearance between outer lip of armrest and canopy sill

Right: not applicable

Left: not applicable

The actual testing and measuring of the subjects in the seat positions were conducted and photographed (see Attachment 1).

g. Figure III-1 of Attachment 1 shows the mesh net survival vest, SRU-21/P. The illustration shows that, when the vest is filled with survival items, the lower right pocket will interfere with the oxygen controller of the suit. The vest will not stretch during the inflation of the pressure suit. Figure III-2 shows the position of the arms when the LPU-3/P underarm life preservers are worn.

h. The test results are presented herein. Figures III-3, III-4, and III-5 show Major Villaret, the pilot of this aircraft, in an extra large regular A/P22S-6 suit in the uninflated and inflated (3.5 PSI) state with the seat in the normal operating (flying) position and with the seat in the completely up position. In these figures, it is easily noted that the cockpit seat is "off-to-the-side" on the right by 3 inches. The pilot can reach the D-ring (Figure III-3) without suit pressurization but finds it somewhat difficult to reach the D-ring with both hands when the suit is inflated. He is shown using the alternate method of one hand on the D-ring and the other hand on the wrist to assist in pulling the ring. In the uninflated state, he can reach all required instruments. With both hands on the D-ring, his head is only 1 inch from the headrest, there is 4 inches clearance at the left arm and 3 inches at the right arm, and he has good clearance of the entire body when the seat is raised to simulate egress. His right arm appears to be wedged but note the distance between the sill and the left arm. His arm will rub on the right side. The pilot is able to put his feet only partly in the stirrups. At this point, the pilot's head (helmet) is 6 inches from the headrest. The body (spinal) and back of seat relationship is unknown, but it is the pilot's opinion that if he were forced in an emergency to eject when the suit is inflated, he could do so. All other subjects were observed in the above manner.

i. The subjects commented while wearing both outfits in each aircraft that the head mobility and visual field were limited.

2. CONCLUSIONS (The conclusions are also considered to be applicable to the rear cockpit of the F-104B and F-106B aircraft, respectively.)

a. F-104B - A/P22S-2 and A/P22S-6 uninflated

(1) To unstow the D-ring, a single-handed grip of the D-ring may be necessary since a two-handed grip is impaired due to the diameter of the wrist rings. It may be possible to grasp the D-ring with both hands prior to activation of the seat due to slack in the D-ring cable.

(2) Clearance of the pilot through the escape envelope is considered possible in all sizes of the outfits.

(3) The helmet does not rest against the headrest during ejection procedures due to the necessity for the pilot to reach forward in an effort to grasp the D-ring.

(4) It is possible to reach and manipulate all the necessary forward controls. The difficulty lies in the aft areas of the shoulders on both sides in both reach and vision.

b. F-104B or F-106B - A/P22S-2 and A/P22S-6 uninflated

Subjects wearing either of the pressure suits, seated in the front cockpit of the F-104B or F-106B aircraft with the suit in the uninflated state can reach all necessary instruments, radio, stick, throttle, D-ring, and armrest triggering device with very little difficulty. The knees and legs of the subjects were in good egress position. The subject's head position presented questionable measurements with regard to distance from the headrest. Most subject's heads were 3 to 5 inches away from the seat headrest. This position does not assure the subject of ideal body-spinal alignment before and during egress procedures.

c. F-104B - A/P22S-2 and A/P22S-6, inflated (3.5 PSI)

(1) In most instances, the D-ring grasp was unattainable with a two-hand grip (see Figure III-3). Inflated thigh (ballooning) areas of the suit and stiff torso prevent reach.

(2) Clearance of the subjects in all suit sizes was somewhat marginal since the shoulder-elbow portions of the suit rubbed the canopy rail, at least on the right side.

(3) Although the pilot did not grasp the D-ring, an attempt was made to assume the ejection position. The helmet was not resting against the headrest during ejection procedure.

(4) A minimal manipulation of the flight controls is possible at 3.5 PSI.

(5) When the seat is raised, with the outfit inflated simulating egress, the subjects in coverall sizes medium regular and below of the A/P22S-6 and large regular and below of the A/P22S-2 had no appreciable problems clearing the canopy sills in the arm-elbow and shoulder areas.

d. F-106B - A/P22S-2 and A/P22S-6 uninflated

(1) Grasping of the ejection handles was possible in all suit sizes. There were, however, in the larger sizes of suits improper positioning of the elbows (on, instead of inside, the elbow guards) due to the bulk of the LPU underarm preservers.

(2) Clearance of the pilot through the escape envelope is considered possible in all sizes of the suits.

(3) The helmet does not rest against the headrest during the ejection procedure in most instances.

(4) It is possible to reach and manipulate all the necessary forward controls. Problems were encountered in the aft areas of the shoulders on both sides in both reach and visibility. Slight difficulty was encountered due to the wrist ring coming in contact with the throttle.

e. F-106B - A/P22S-2 and A/P22S-6 inflated

(1) Clearance of the pilot through the escape envelope in most suit sizes induced arm rubbing.

(2) The helmets did not make contact with the headrest.

(3) Reach and manipulation of all forward controls was possible but with some difficulty aft of the shoulder line.

f. The visual field in both the A/P22S-2 and A/P22S-6 helmets should be measured and in conjunction, an improvement in helmet mobility is required.

TABLE III - 4
NUDE DIMENSIONS OF SELECTED SUBJECTS

Dimension	Albert Villaret Inches	Edward Woelfel Inches	Bronwood Harrison Inches	Marvin McCall Inches	John Everett Inches	Harry Lees Inches	Hugh Palumbo Inches	Toribio Cruiz Inches
Shoulder Breadth	19.55	20.6	19.5	18.75	17.5	19.5	20.3	18.4
Chest Breadth	12.65	13.1	12.95	13.2	11.5	12.9	14.0	12.45
Waist Breadth	12.2	12.3	12.05	11.7	10.5	12.35	12.7	11.15
Elbow-to-elbow Breadth	20.25	22.3	22.35	19.7	19.4	22.05	22.45	19.65
Chest Depth	10.5	10.95	10.35	9.9	8.8	10.5	9.5	8.7
Waist Depth	9.35	9.3	9.7	8.7	7.55	10.5	10.4	8.4
Height	74.65	73.0	69.4	68.25	67.2	70.3	69.8	68.05
Chest Circumference	41.0	42.9	40.6	40.2	35.9	42.0	43.5	38.7
Waist Circumference	35.1	35.9	36.0	33.9	28.2	37.7	37.3	33.0
Shoulder Circumference	49.2	51.8	47.9	48.0	43.5	51.2	50.1	46.4
Weight (pounds)	207	218	186	177	143-3/4	213	192.3	158.25
Crotch Height	35.8	33.8	32.6	30.3	31.1	31.9	30.6	31.7
Buttock Breadth	16.5							

TABLE III - 5
COMPATIBILITY TEST OF A/P22S-2 AND A/P22S-6 OUTFITS IN F-104B AND F-106B AIRCRAFT
(7-9 OCTOBER 1969)

Test No	Subject	Coveralls Type/Size	Outfit Pressure (PSIG)	Ejection Seat Handle Operation	Helmet-Headrest Clearance (inches)	Elbow-Canopy Rail Clearance (inches)		Seat Position			Able to Reach Required Switches (etc)	Elbows Inside Guards	Other Comments
						Left	Right	Down	Mid	Up			
F-104B													
1	Villaret	S-6/XLL	0	yes	1.0	4	3		X		yes	n/a	Seat vertical position that pilot uses when flying aircraft. It was the pilot's opinion that he could eject even with elbows rubbing.
2	Villaret	S-6/XLL	3.5	yes (hand)	6.0	2	0		X		yes		
3	Villaret	S-6/XLL	3.5	yes (hand)	6.0	2	0			X	n/a		
4 & 5	Lees	S-6/LR	0	yes	—	4.5	3				yes		
6	Lees	S-6/LR	3.5	no	—	—	0			X			
7	Cruiz	S-6/MR	0	yes	4-5.0	clears	clears		X		yes		
8	Cruiz	S-6/MR	3.5	no	7.0	clears	clears		X		yes		
9	Everett	S-6/SR	0	yes	1.5	clears	clears		X		yes		
10	Everett	S-6/SR	3.5	no	6.0	clears	clears				yes		
11	Lees	S-2/XLR	0	yes (hand)	2.5	clears	clears		X		yes		
12	Lees	S-2/XLR	3.5	no	—	clears	0			X	n/a		
13	McCall	S-2/LR	0	yes	2.5	3.75	2		X		yes		
14	McCall	S-2/LR	3.5	yes (hand)	5.5	clears	0			X			
15	Cruiz	S-2/MR	0	yes	5.0	clears	clears		X		yes		
16	Cruiz	S-2/MR	3.5	yes (hand)	7.0	clears	clears			X	n/a		
17	Everett	S-2/SR	0	yes	2.0	clears	clears		X		yes		
18	Everett	S-2/SR	3.5	no	5.5	clears	clears		X		yes	n/a	
19	Everett	S-2/SR	3.5	no	5.5	clears	clears			X	n/a		
F-106B													
1 & 2	Everett	S-6/SR	0	yes	0	clears	clears		X		yes (down pos)	yes	
3 & 4	Everett	S-6/SR	3.5	yes	4.0	0	0		X		yes (down pos)	no	
5 & 6	Everett	S-2/SR	3.5	yes	2.0	clears	clears		X		yes (down pos)	no	
7 & 8	Everett	S-2/SR	0	yes	0	clears	clears		X		yes (down pos)	no	
9 & 10	Woefel	S-6/XLL	0	yes	3.0-5.0	clears	clears		X		yes (down pos)	no	
11 & 12	Woefel	S-6/XLL	3.5	yes	5.0	0	0		X		yes (down pos)	no	
13 & 14	Palumbo	S-6/LR	3.5	yes	4.0-5.0	0	0		X		n/a	no	Elbows wedged between canopy rails with outfit inflated.
15 & 16	Palumbo	S-2/LR	3.5	no	2.0-3.0	0	0		X		yes (down pos)	no	Left wrist ring interference with throttle.
17 & 18	Palumbo	S-6/LR	0	yes	1.0	0	0				yes (down pos)	no	
19 & 20	Palumbo	S-2/LR	0	yes	2.0	2	0		X		yes (down pos)	no	
21 & 22	Harrison	S-6/MR	0	yes	1.0	3	2		X		yes (down pos)	yes	Arms wedged between canopy rails w/outfit inflated; however, pilot said he could eject.
23 & 24	Harrison	S-6/MR	3.5	yes	5.0	1	0		X		yes (down pos)	no	
25 & 26	Cruiz	S-2/MR	0	yes	1.5	clears	clears		X		yes (down pos)	no	
27 & 28	Cruiz	S-2/MR	3.5	yes	10.0	0	0		X		yes (down pos)	no	
29 & 30	Lees	S-2/XLR	0	yes	0	clears	0		X		yes (down pos)	no	Vision is limited.
31	Lees	S-2/XLR	3.5	no	3.0	0	0		X		yes	no	

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ATTACHMENT 1 to APPENDIX III

(Figures III-1 through III-5)

NOT REPRODUCIBLE

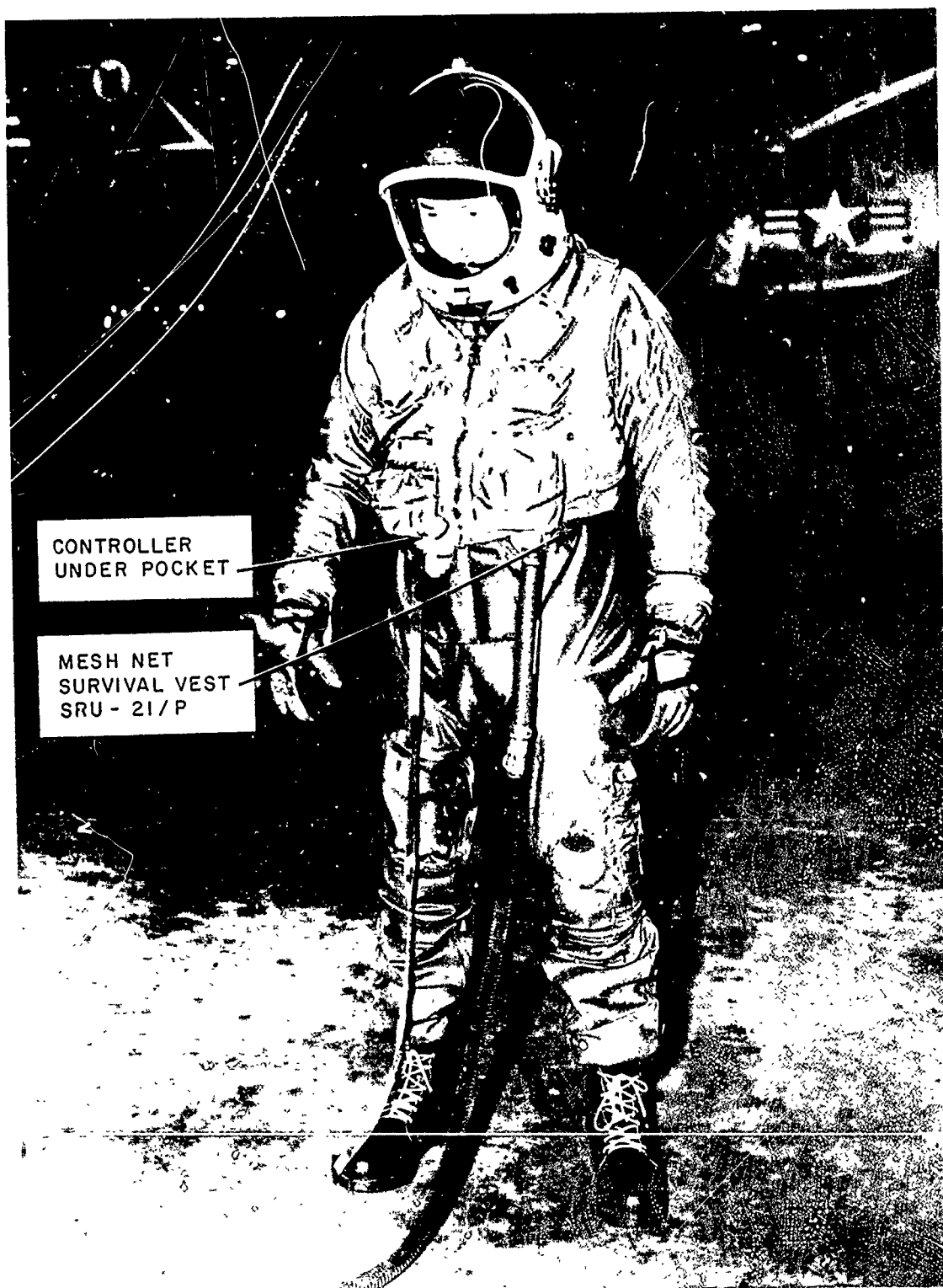


Figure III-1. Pilot Wearing Mesh Net Survival Vest Showing Interference of Lower Right-Hand Pocket with Oxygen Controller of Suit - TSgt Harry E Lees, A/P22S-6 Suit (Uninflated)



Figure III-2. Pilot Wearing Underarm Life Preserver,
TSgt Harry E Lees, A/P22S-6 Suit (Uninflated)

NOT REPRODUCIBLE

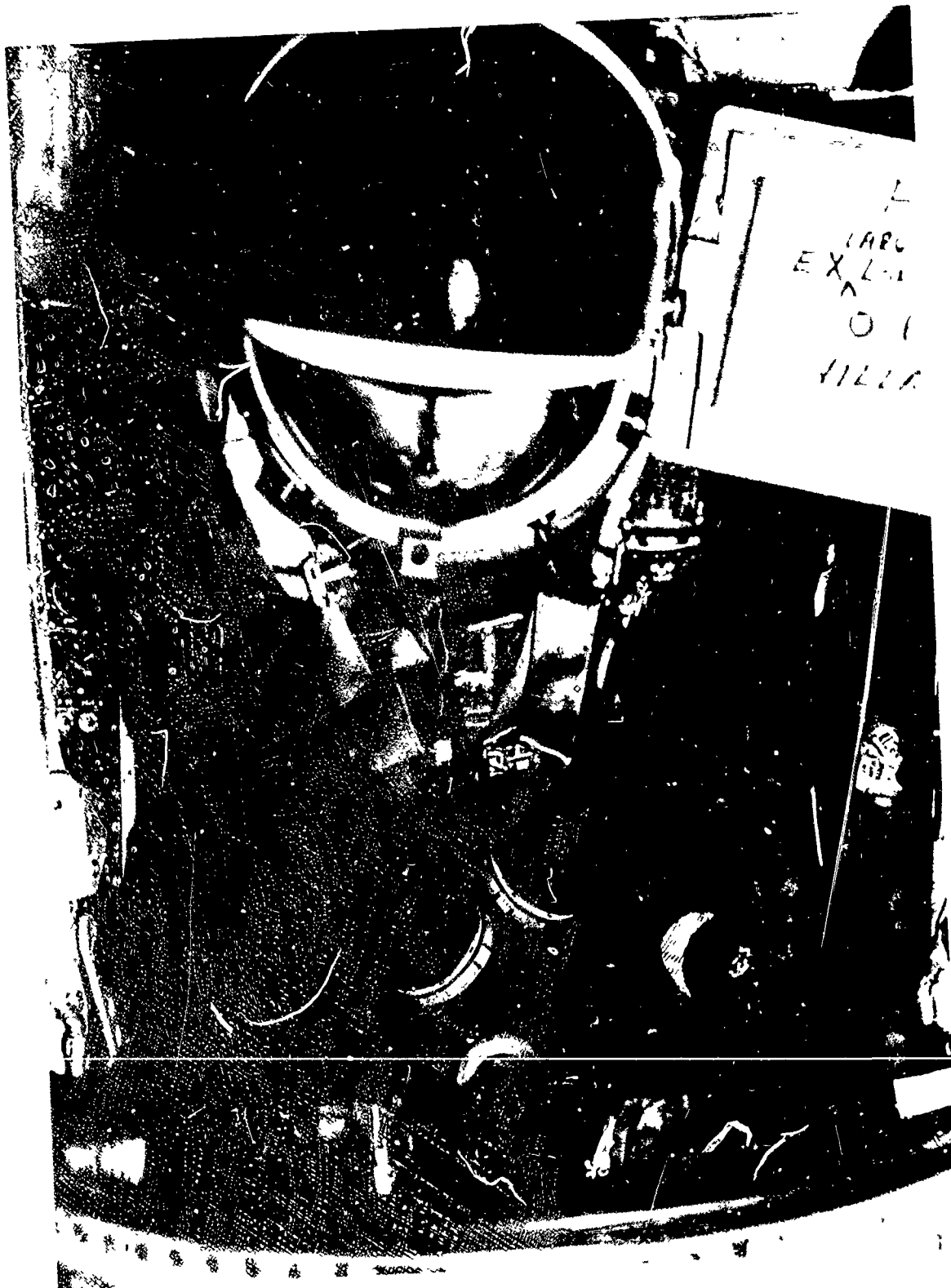


Figure III-3. View Showing Canopy Sill Clearance and D-ring Grasp -
F-104B Aircraft, Extra Large Long, A/P22S-6 Suit (Uninflated)



Figure III-4. View Showing Canopy RH Sill Interference and One-Handed D-ring Grasp - F-104B Aircraft, Extra Large Long A/P22S-2 Suit (Inflated to 3.5 PSI) Seat in Normal Operating Position

NOT REPRODUCIBLE

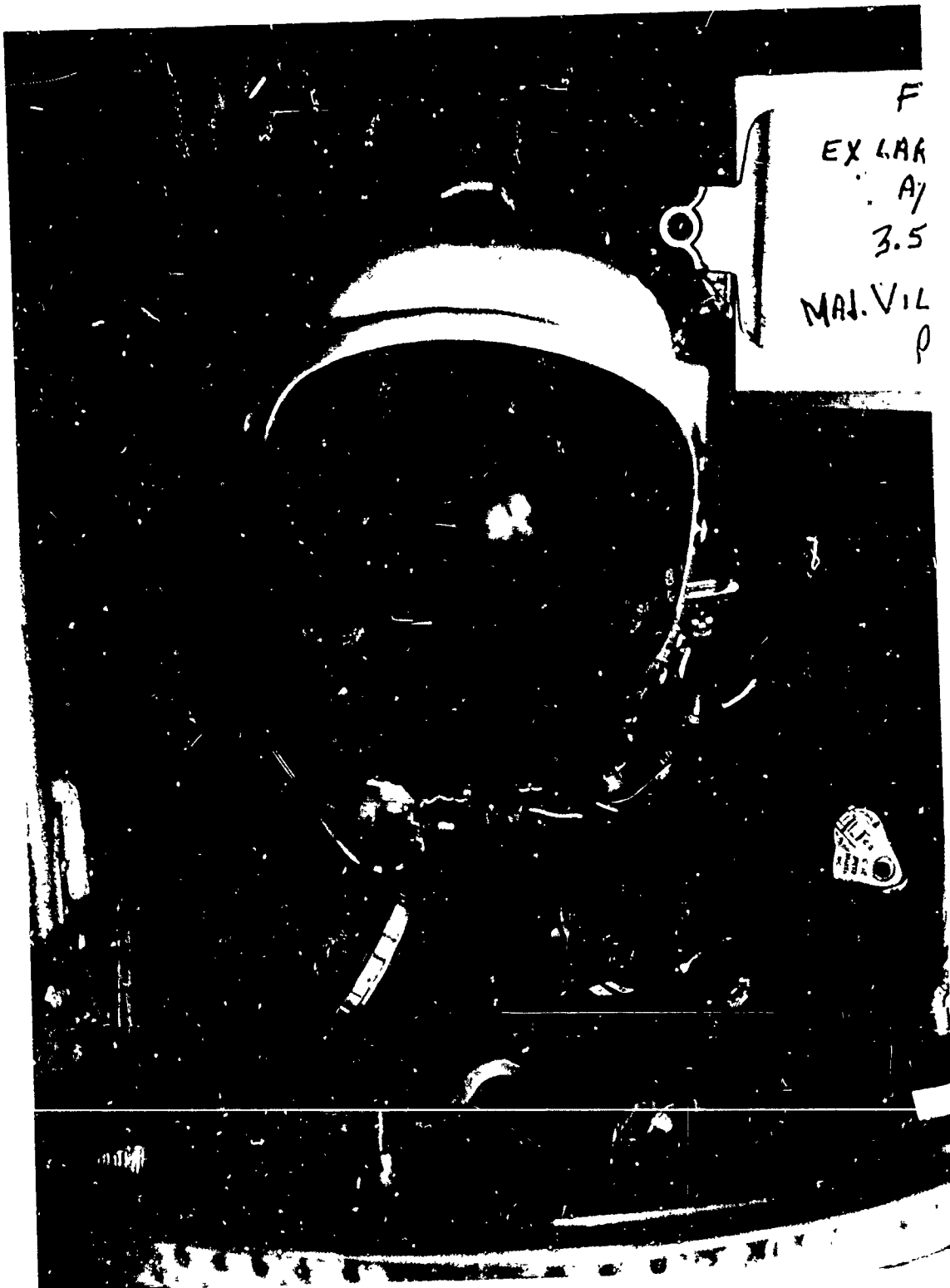


Figure III-5. View Showing Canopy RH Sill Interference and One-Handed D-ring Grasp, F-104B Aircraft, Extra Large Long A/P22S-6 Suit (Inflated to 3.5 PSI), Seat in Completely Up Position

ATTACHMENT 2 to APPENDIX III

PERSONS CONTACTED AT 4756th USAF HOSPITAL, TYNDALL AFB, FLA

Captain William Harrison, Air Defense Weapon Center (ADWC),
Chief, Life Support Branch, WCOTT-L,
Tyndall AFB

Major Edward A. Woelfel, Pilot, ADC, Tyndall

Major Bronwood Harrison, Pilot, ADC, Tyndall

TSgt Shirley J. Blackburn, Pressure Suit Tech, Tyndall

MSgt Marvin C. McCall, Pressure Suit Tech, Tyndall

TSgt Harry E. Lees, Pressure Suit Tech, Tyndall

SSgt Toribio Cruz, Pressure Suit Tech, Tyndall

A2C John M. Everett, Pressure Suit Tech, Tyndall

TSgt Harvey A. Childress, 4750th Test Sqdn Motion Picture, Tyndall

A1C Thomas W. Parker, 4750th Test Sqdn Motion Picture, Tyndall

Major Albert L. Villaret, Flt Cmdr, 319 Fighter Interceptor Sqdn
(FIS), Homestead AFB

Sgt Wm D. Moore, Jr., Egress Tech, 319 FIS, Homestead

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COCKPIT COMPATIBILITY STUDIES CONDUCTED WITH AIRCREW MEMBERS WEARING HIGH ALTITUDE FLYING OUTFITS IN B-57D, B-57F, F-104A, F-104B, F-106A, AND F-106B AIRCRAFT		
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13. ABSTRACT		
This report presents anthropometric measurements of the aircrewmembers, dimensions of the aircrewmembers while wearing the High Altitude Flying Outfit (HAFO) in the uninflated and inflated state, and measurements of the clearance between the aircraft cockpit canopy sills and the aircrewmembers seated in the ejection seat when the seat is in the bottom, neutral, and fully raised positions. All aircrewmembers were measured in accordance with WADC TR 56-365, <u>A Height-Weight Sizing System for Flight Clothing</u>. The aircrewmembers were clothed (fitted) according to these measurements. The dimensions of the aircrewmembers in the HAFO and the dimensions of the aircraft cockpit canopy sills and ejection seat were evaluated with regard to compatibility and crew-member mobility, visibility, and ability to carry out emergency escape procedures and normal aircraft control operations. It was within these areas that tests and evaluations were conducted, with the results noting those conditions which were unsatisfactory or would degrade the operational capabilities of the aircrew member to function under normal and emergency conditions. The outfits and aircraft referenced in this report were compatible with the outfits uninflated; however, with the outfits inflated, some difficulty was experienced. (This abstract is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of the Crew Support Division (ASD/ENCC), Directorate of Crew and AGE Subsystems Engineering, Wright-Patterson Air Force Base, Ohio 45433.)		

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	Compatibility						
	Anthropometrical						
	Canopy Sills						
	D-Ring						
	Hand Triggering Device						
	Body-Spinal Alignment						
	Headrest, Ejection Seat						
	Indicated Size Range						
	Microphone Noise						
	Anthropology						
	Anthropometry						
	Height-Weight Sizing Range						

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